Transports
Canada

TP 1936E

**Transportation
Development
Centre**

Montreal, Quebec

TDC 1984
PROJECT
DIRECTORY

Canada

TDC
Project Directory

1984

Transportation
Development Centre

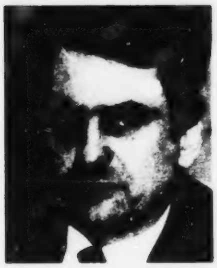
Transport Canada

Montreal, Quebec

© Department of Supply and Services
Catalogue No. T48-17/1984E
ISBN: 0-662-12885-0
ISSN: 0225-6436

Également disponible en
français sous le titre
"CDT Répertoire des projets"
No. de catalogue T48-17/1984F

Minister of Transport
Ministre des Transports



Transportation is vital to Canadians and to the Canadian economy. It is vital in terms of the government's commitment to economic renewal. It is vital to achieving balanced economic growth and as an instrument for regional economic development.

Given the importance of transportation to Canada, it is essential that government and industry work together to make the national transportation system as safe, efficient, and reliable as possible. This is a challenge that requires more innovation and creativity, and that we employ all the latest techniques to move people and goods from coast to coast in the most effective manner.

Transport Canada, through its Transportation Development Centre, has taken up this challenge through a long-term, systematic program of transportation research and development (R&D). The Transportation Development Centre carries out its R&D program in cooperation with other federal departments, provincial governments, and the transportation industry. As outlined in the 1984 Project Directory, this joint effort has produced impressive results.

I call upon all members of the transportation community to join in this cooperative effort to make ours a modern national transportation system that meets the needs of all Canadians and contributes to our economic well-being.

The Honourable Donald Frank Mazankowski
Minister of Transport

Preface

This is the eighth in a series of annual project directories describing the research and development activities of the Transportation Development Centre (TDC). This volume covers selected projects active during the reporting period of June 1983 to July 1984.

The directory is organized according to the principal thrust areas of TDC's research and development program in transportation technologies: rail, surface, air, and marine.

Each project description briefly relates the rationale for the work, its objectives, and the methodology for the achievement of these objectives. Also given are an account of completed work, the name of the performing organization, and titles of reports.

The project description is accompanied by supplementary information consisting of the work schedule, project and file numbers, funding sources, and the name of the project officer in charge.

Table of Contents

Introduction 1

Rail Technology 9

Rail Electrification

- Railway Electrification Demonstration 13
- Electric Locomotive Conceptual Design 14
- Hybrid Locomotive Study 15
- Clearance Testing for 50 kV Operation 17

Railway Equipment

- Switcher Locomotive Study 18
- Stirling Cycle Locomotive Engine 19
- Medium-Speed Diesel Combustion Research 21
- Microprocessor Control of Locomotive Propulsion Electronics 22
- Two-Axle Locomotive Steerable Truck 23
- Frame-Braced Freight Car Truck Development 25
- In-Service Evaluation of Radial Axle Trucks 27
- Tank Car Thermal Response Study 29

Train Systems

- Train Dynamics Simulation 30
- Train Data Recording System Evaluation 31
- Train Data Recording System Development 33
- Locomotive Speedometer Evaluation 35
- End-of-Train Monitoring 36
- Review of Signal Transmission Technology for Freight Trains 37

Track Systems

- Rail Wear and Fatigue Model 38
- TDC/CP Cooperative Rail Research Program 39
- Rail Grinding Optimization 41
- Snowmaster — Conceptual Design 42
- Induction Track Hardening System 43

Signalling, Communications & Control

- Study of LIC Application on Mainline Track 44
- Automatic Rail Car Identification System 45
- Railway Colour Light Signal 46
- Railway Level Crossing Signals 47

Rail Passenger Technology

- Railbus: Pilot Vehicle Development 48
- Unsprung Mass Alternatives for the LRC 49
- B.C. Rail RDC Evaluation 51
- Human Factors in Rail Passenger Car Design 52

Intermodal Rail Systems

- Intermodal Terminal Operations Simulation 53
- Convoy Canada Demonstration 54

Surface Technology 57

Highway Transportation

- Soil Stabilizer Evaluation 61
- Embankment Reinforcement Design 62
- High-Capacity Coach Design 63
- Weights and Dimensions Study 65
- Ni/Zn Battery Research for Cold Weather Engine Starting 67
- Ignition of Propane in Diesel Engines 69

Urban Transportation

- Urban Transportation Energy Management 70
- SailRail Application to Transit 71
- Shared Vehicle Fleets: Institutional Issues 72
- Hybrid Vehicle Research 73
- Large Moli Battery Development 75
- Advanced Battery Charger for Electric Vehicles 76
- Lightweight Bogie for Intermediate Capacity Transit Systems 77

Off-Road Vehicles

- Study of Aerobac as an Airport Emergency Vehicle 78
- Arctic Snowmobile Design Study 79
- Evaluation of a Hybrid Cellular Air Cushion Skirt 80

Tracked, Levitated Vehicles

- Comparative Study of TransRapid EMS and Electrified LRC 81
- Homopolar Linear Synchronous Motor Investigation 82

Transportation for the Elderly and the Handicapped

- Wheelchair Access to an Intercity Coach 83
- Commuter Rail Access for Disabled Persons 84
- Computerized Scheduling and Routing of Special Public Transit Services 85
- Modular Transfer Vehicle Development 87
- Vehicle Selection Guidelines 88
- Field Evaluation of Quick-Release Hand Controls for Automobiles 89
- Motorized Mobility Aids: Status and Safety Issues 90
- Pedestrian Crosswalk Systems for the Elderly and the Handicapped 91

Multimodal Transportation

- Transport Management Game 92
- Application of Fuzzy Sets to Risk Assessment 93
- Transportation Safety: an R&D Planning Framework 94

Air Technology 97

Safety & Regulation

- Smoke Mask Criteria 99
- Aircraft Simulator Response 101
- Light Bulb Filament Impact Dynamics 103

Navigation & Airports

- Offshore Air Terminal 105
- STOLport Design Research 107
- Mobile Air Terminal 109
- Microwave Landing System Antenna Development 110
- Cycle Charged Diesel Power Supply 111

Airframe & Propulsion

- Innovative Aircraft Configurations 113
- Fuel-Efficient STOL Aircraft 115
- Mixed Flow Turbine Study 116
- Gas Turbine Ceramics Technology 117
- Advanced Propeller Designs 118

Marine Technology 121

Arctic Marine Technology

- M.V. *Arctic* Scientific Program 123
- M.V. *Arctic* Bow Redesign Study 125
- Thyssen/Waas Icebreaking Bow Technology Transfer 126
- Segmented Model Ice Tests 127
- Antarctic Icebreaking Tests 128
- Arctic Ship Task Analysis and Navigability Study 129
- Hull Ice Loads, USCGC *Polar Sea* 1983 Arctic Voyage 131
- Propeller/Ice Finite Element Model: Phase II 132
- Ice Nozzle Strength 133
- Ice Forces on Nozzle Propellers 135
- Protection of Propellers in Ice 136
- Ultrasonic Doppler Velocimeter for Icebreakers 137
- Hull Corrosion and Coatings 138

General Ice Research

- Icebreaking Resistance of SWATH Ships 139
- Ice Loads on Fishing Vessels 140
- Air Cushion Technology Research 141
- Advanced ACIB Concepts Design Study 142
- Air Cushion Icebreaking Bow Evaluation Program 143
- Ice Information System Development 144
- Shipboard Multi-Task Ice Data Analysis System 145
- Remote Sea Ice Thickness Sensor Development 146
- Portable Ice Thickness Sensor 147
- Ice Failure Model 148
- Mechanical Icebreaking and Removal Techniques 149
- Demonstration of Harbour Ice Management Techniques 150

General Marine Research

- Energy-Efficient Ships: a Documentation Study 152
- Alternative Fuels for Marine Propulsion 153
- Energy-Efficient Tug and Barge 154
- R.B. 211 Combined Cycle Study 155
- Welding Methods for Aluminum 156
- Hydrostatic Stern Tube Bearing 157
- Concrete Paving Blocks for Marine Terminals 158

Report Listing 159

Introducing the Transportation Development Centre

The Transportation Development Centre (TDC) was formed by Transport Canada in 1970 to study, promote, and manage the application of science and technology towards a more efficient and effective Canadian transportation system. Located in Montreal, TDC administers an ongoing program of research and development (R&D) activities, all of which are contracted out to the private sector.

TDC mission

TDC's mission is twofold:

- to provide components of Transport Canada with specific data, research, and demonstration projects to assist them in their operational, regulatory, policy planning, and evaluation functions;
- to undertake exploratory research and development addressing requirements in transportation technology and systems that are high risk, long-range, and national in scope.

R&D program

TDC's R&D program covers all modes of transportation: marine, air, rail, and surface. Included in the surface mode is road, off-road, and solids pipeline transport. The major emphasis is on rail freight and Arctic marine, each of which accounts for about 30% of TDC's annual R&D expenditures. Special attention is being given to an R&D program aimed at improving transportation accessibility for elderly and handicapped Canadians.

TDC uses a consultative process to ensure that research and development projects are relevant to Transport Canada's needs and respond to the priorities of transportation industry. To identify R&D thrust areas, TDC consults with modal advisory boards composed of representatives of marine, air, surface, and rail industries.

In implementing its R&D program, TDC relies on a multi-disciplined staff of professionals. Each TDC project officer is given complete responsibility for achieving individual project R&D objectives within approved budgets and schedules. To assist the staff and to ensure effective program direction and control, TDC has established a computerized management information system (MIS). The MIS is integrated with the Transport Canada finance function and provides up-to-date information on project status and program costs.

TDC Organization

TDC is organized into three operating divisions: Current Technology, Advanced Technology, and Technology Applications.

Current Technology projects are concerned with R&D aimed at improving conventional transportation technology. These projects involve developing prototypes and conducting test programs. Follow-on work for current technology development frequently takes the form of in-service evaluation by transport operators.

Advanced Technology projects investigate new concepts and innovative technical solutions that promise to overcome shortfalls in systems using conventional technology. Developments resulting from these projects are supported by quantitative assessments of the economics and user acceptability of the technology.

Technology Applications projects involve practical testing and evaluation of technological developments, including the systems analysis studies needed to establish a base for assessment and comparison. Technology demonstration projects are directed towards introducing new methods, equipment, and systems on an experimental basis.

Library

TDC also administers a comprehensive transportation technology library. The library has approximately 15,000 books and reports, 5,000 documents on microfiche, an audiovisual collection, a pamphlet collection, and Statistics Canada publications. As well, the library subscribes to over 500 periodicals. Underlining the library's effectiveness is on-line access to three database systems: DIALOG, ORBIT, and CAN/OLE. Supplementing these systems, the library has on-line access to the holdings of about 500 Canadian libraries through the University of Toronto Library Automation System (UTLAS).

Funding

The Centre's research projects are funded in one of two ways: wholly from TDC's R&D budget, or on a cost-shared basis with industry, provinces, and/or other government organizations.

Below is a list of abbreviations used in the Project Directory to identify some funding sources:

CATA: Canadian Air Transportation Administration, Transport Canada
CEA: Canadian Electrical Association
CMTA: Canadian Marine Transportation Administration, Transport Canada
CSTA: Canadian Surface Transportation Administration, Transport Canada
DND: Department of National Defence
DFO: Department of Fisheries and Oceans
DRIE: Department of Regional Industrial Expansion
DSS: Supply and Services Canada
EMR: Energy, Mines and Resources Canada
MSERD-E&H: Minister of State for Economic and Regional Development (now DRIE) — program for the elderly and the handicapped
NRC: National Research Council Canada
TDC-AAMP: Controlled allotment of funds allocated by CMTA to TDC for its Augmented Arctic Marine Program
TDC-ARFP: Controlled allotment of funds managed by TDC for its Augmented Rail Freight Program

Publications

Each TDC project is documented by a technical report. A listing of reports printed in 1984, along with ordering procedures, appears on page 159.

Unsolicited Proposals

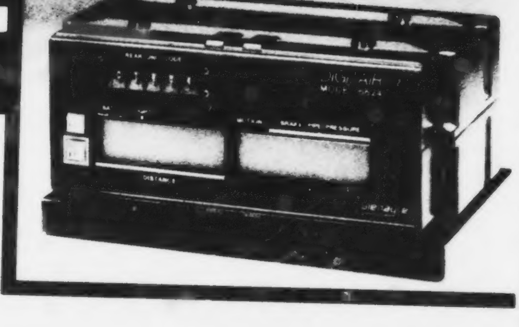
TDC also considers unsolicited proposals for R&D projects. These submissions are received through the **Unsolicited Proposal Program** administered by Supply and Services Canada. (Director, Programs Branch, Science and Professional Services Directorate, Supply and Services Canada, Hull, Quebec, K1A 0S5, (819) 997-7428.)

RESEARCH AND DEVELOPMENT HIGHLIGHTS

SUBSTANTIAL R&D ACHIEVEMENTS HAVE BEEN MADE DURING THE PAST YEAR. SOME OF THESE ARE ALREADY BENEFITING CANADIAN TRANSPORT INDUSTRY AND THE TRAVELLING PUBLIC; OTHERS HAVE POTENTIAL FOR IMPORTANT LONG-TERM IMPLICATIONS FOR CANADA'S TRANSPORTATION SYSTEMS. WHILE THE TDC PROJECT DIRECTORY ITSELF IS A SAMPLING OF THE CENTRE'S R&D ACTIVITIES, THIS SECTION IS A FOCUS ON CERTAIN KEY PROJECTS.

Developed by Glenayre Electronics of Vancouver under contract to TDC, the "end-of-train" unit is a computerized device (left) that is fitted to the coupling of the last car and provides the engineman with a digital display (right) of end-of-train brake pipe pressure and low pressure alarms in the locomotive cab. The system also incorporates a precise odometer, a rear car motion detector and a marker light.

CN and CP Rail estimate that $65 million a year could be saved if trains were equipped with end-of-train units in place of cabooses.



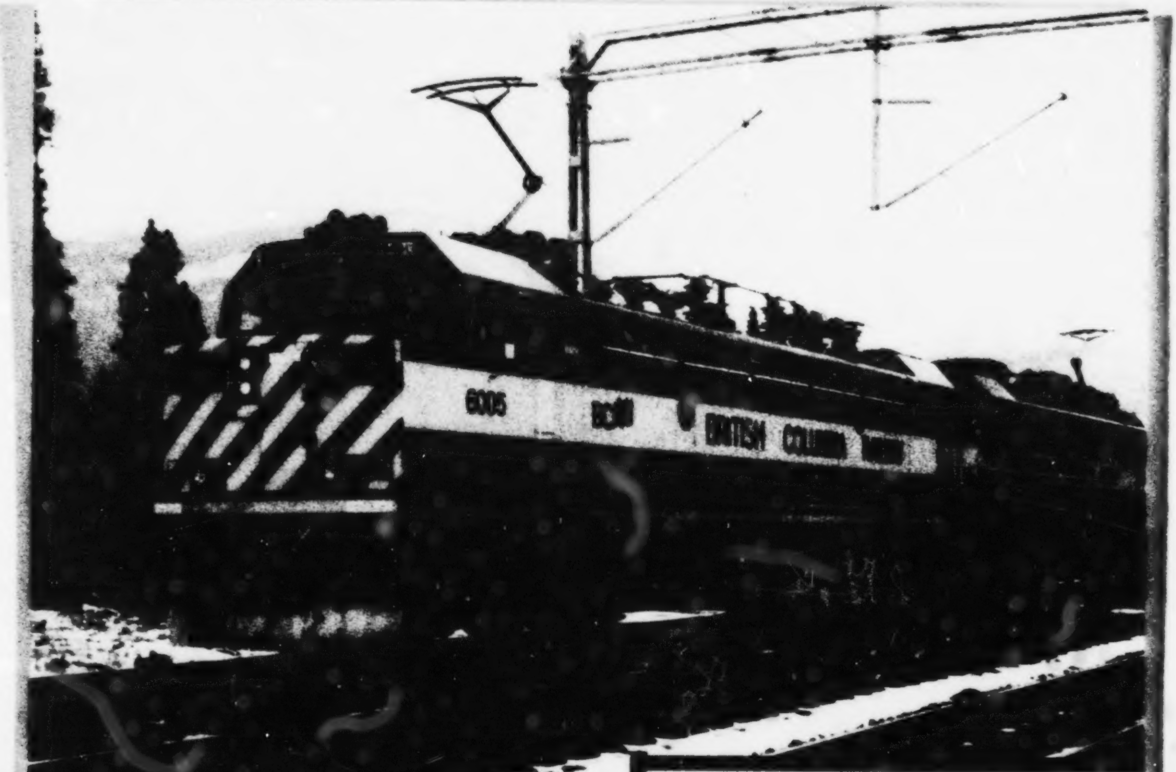
The new bow form (left) designed for the M.V. *Arctic* as a result of a TDC project will upgrade this cargo vessel's ice transiting capability. The new design was developed by Melville Shipping Limited after an analysis of various bow forms and a series of comprehensive tests in Canadian, German and Finnish ice basins. The modification to the bow of the M.V. *Arctic* will be completed in 1986.

While aimed at improving the performance of the M.V. *Arctic*, this research project has also generated invaluable data for the design of future generations of icebreaking cargo vessels.

TERRA TOURS

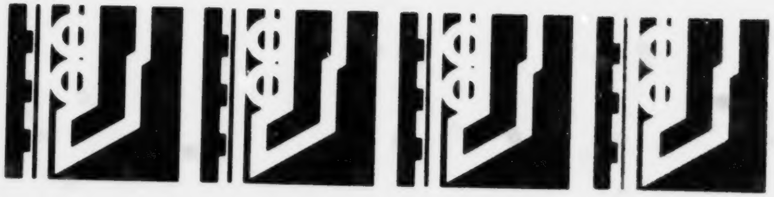
Developed under contract to TDC by TES Limited of Ottawa, this specially equipped intercity bus features dedicated wide doors and a self-contained hydraulic lift that provides a dignified boarding system for wheelchair bound travellers.

The first of its kind in commercial operation in North America, the bus is in service as a part of a three-year demonstration project with TerraTransport in Newfoundland.



The 132 kilometre Tumbler Ridge – Anzac electrified rail section of B.C. Rail is one of three 50 kV commercial frequency systems in operation in the world today. The $55 million electrification demonstration project was inaugurated in May, 1984 after completion within cost and time schedules. Over the next ten years, the branch line is expected to save 90 million litres of high grade diesel fuel and haul an average of 8.5 million tons of coal annually. TDC awarded $2 million in contracts to Canadian Pacific Consulting Services Limited and B.C. Rail to support technical research and data collection.

RAIL
TECHNOLOGY



Rail Technology

An efficient and effective national rail transportation network is vital to the country. For Canadian industry, the cost of delivering goods by rail, especially bulk commodities, influences their competitiveness in both domestic and foreign markets. For the travelling Canadian public, safe and reliable rail service is essential.

To help meet the needs of these distinct user groups, TDC funds research and development projects in rail freight and rail passenger transportation. These projects are undertaken in conjunction with railways, railway equipment manufacturers, and government-supported research organizations.

RAIL ELECTRIFICATION

TDC's research and development in rail electrification will prepare Canada for possible future electrification of certain sectors of the country's rail system. TDC is supporting research in the following areas: establishing the technical and economic characteristics of electrification; developing guidelines for electrification including those needed for signalling and communications; evaluating alternative electric and hybrid locomotive designs; and, identifying the system requirements and the related costs of specific electrification projects.

RAILWAY EQUIPMENT

Enhanced performance characteristics of Canadian freight cars coupled with fuel-efficient motive power are the main objectives of the R&D efforts in this area. Research to develop locomotive engines that are capable of operating on alternative and off-specification fuels is underway.

Research is being conducted in reducing fuel consumption of locomotives through more efficient management of motive power. Micro-electronics and power electronics are being applied to locomotive traction systems, where the data acquisition system and the related software will be tested in the laboratory and in the field.

Another area of R&D involves freight car systems. Research in this area is intended to enhance the performance characteristics of Canadian freight cars in terms of safety, energy efficiency, maintenance, and life-cycle costs. Specifically, TDC is supporting programs involving truck technology, tank car safety, and maintenance.

TRAIN SYSTEMS

Safety, energy efficiency, and productivity of train operations can be improved by developing train data, control, communication, and simulation systems. With this in mind, TDC is supporting research in the following areas:

- a train dynamics simulator for exploring the longitudinal behaviour of trains;
- data recording and condition monitoring for improved safety of train operations;
- the application of control system technology for improved train handling; and,
- a communications system to transmit data for train control and monitoring.

TRACK SYSTEMS

A thorough understanding of railway track structure design, materials, and maintenance practices will help to improve train performance as well as extend the life of track structure. TDC, in cooperation with Canadian railways, is studying design methods to develop safe and cost-effective track and infrastructure maintenance procedures and better track components and materials through experimentation and field testing programs.

SIGNALLING COMMUNICATIONS & CONTROL

Increased productivity, safety, and reliability of railway operations can be realized through the development and use of improved signalling, communications, and control equipment. TDC has underway several research projects with this object in mind. In particular, TDC is involved with developing advanced train control systems based on communications and micro-electronic technology.

Another research aim is to develop improvements to conventional signalling systems, which would contribute to significant gains in safety and efficiency.

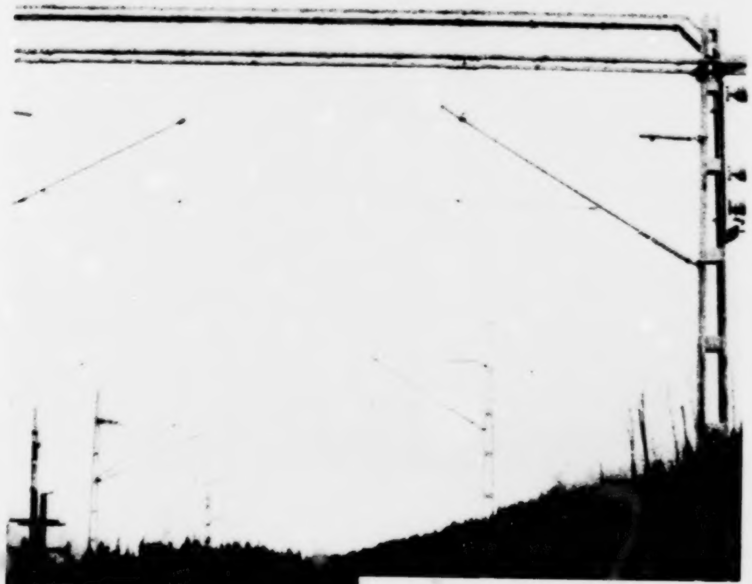
RAIL PASSENGER TECHNOLOGY

TDC is involved with various research and development projects to reduce operating costs and to improve intercity rail passenger service in Canada. Research includes: developing the technology suitable for rail services to remote communities; developing the technology and systems necessary to operate the LRC at its maximum design speed of 200 km/h; and, upgrading the quality and efficiency of current rail services through innovative technology and operational improvements.

INTERMODAL RAIL SYSTEMS

The overall efficiency of intermodal transport operations is affected in large part by the efficiency of terminal and yard operations. TDC is studying computer simulation models and graphic displays to help improve the productivity of container terminal operations.

Also under investigation is an innovative intermodal freight service using purpose-built rail cars.



Catenary masts and track installed for 50 kV B.C. Rail operation

6004
BCR
BRITISH COLUMBIA RAILWAY

B.C. Rail's electrified rail demonstration system is now in operation

Railway Electrification Demonstration

Description

Electrification of Canadian railways has been a major technological concern over the past two decades. The benefits of railway electrification are many, including: increased line capacity, improved locomotive adhesion and speed on gradients, reduced maintenance and energy consumption, and overcoming of problematic site characteristics, such as tunnel ventilation and fuel distribution.

The objective of the current project, a railway electrification demonstration on a 132 km section of British Columbia Railway, is to develop and evaluate 50 kV electrification technology as a railway motive power energy alternative. The demonstration affords firsthand operating experience with state-of-the-art electrification technology under Canadian environmental conditions.

B.C. Rail has constructed a 132 km rail branch line to link its mainline track at Anzac to a new coal mine site at Tumbler Ridge. The branch line, which carries 8.5 million tonnes of coal annually in unit trains, includes two major tunnels, 6 km and 9 km long, with ascending grades against loaded trains. A recent study showed that electrification of tunnel segments alone offers substantial savings by eliminating the need for costly tunnel ventilation.

The demonstration includes acquisition of locomotives, installation of a 50 kV/60 Hz catenary system, construction of a series-capacitor station and a substation for connection to B.C. Hydro, and integration and evaluation of the LIC (location, identification, and control) electronic signalling system. Researchers will develop detailed maintenance and operating procedures, and document every phase of the demonstration from site selection and material procurement to operating evaluations.

Progress to July 1984

Work is continuing on all elements of the demonstration. Track laying of the branch line has been completed. The catenary system has been designed and installed, and the substation has been constructed. Electric locomotives purchased from GM Diesel Division, London, Ontario, are now operating on the branch line.

Contractors

British Columbia Railway, Vancouver, British Columbia
Canadian Pacific Consulting Services Ltd., Montreal, Quebec

Reports

TP 4899E, British Columbia Railway Tumbler Ridge branch line electrification power supply system design, Canadian Pacific Consulting Services Ltd., 1983.

TP 4950E, Railway electrification: engineering and sourcing overhead contact system, 3 volumes, Canadian Pacific Consulting Services Ltd., 1983.

Schedule: May 1983 — June 1985

Funding: Transport Canada/TDC —	$ 2,000,000
EMR —	$ 2,500 000
DRIE —	$ 500,000
Government of British Columbia —	$ 5,000,000
Total —	$10,000 000
B.C. Rail — balance	

Project Numbers: 4960-1, 4785-6, 4908-9, 6032-3, 6036, 4760-1
File Number: D-1465-317
Project Officer: C. Alfred Versailles

Electric Locomotive Conceptual Design

Description

Rail electrification could potentially improve the productivity of Canada's railway system by offering locomotives with improved performance, reliability, and availability. This would result in major cost benefits to the railways.

In this project, researchers are developing a conceptual design of an electric locomotive for a freight service in the Canadian Rockies and Prairies. This is an important step in the introduction of rail electrification as a standardized electric freight locomotive would be less costly to manufacture than a wide variety of configurations and power ratings.

The design will incorporate, wherever possible, the latest state-of-the-art technologies. Once the conceptual design has been determined, manufacturing requirements and costs will be identified, and performance assessed.

Progress to July 1984

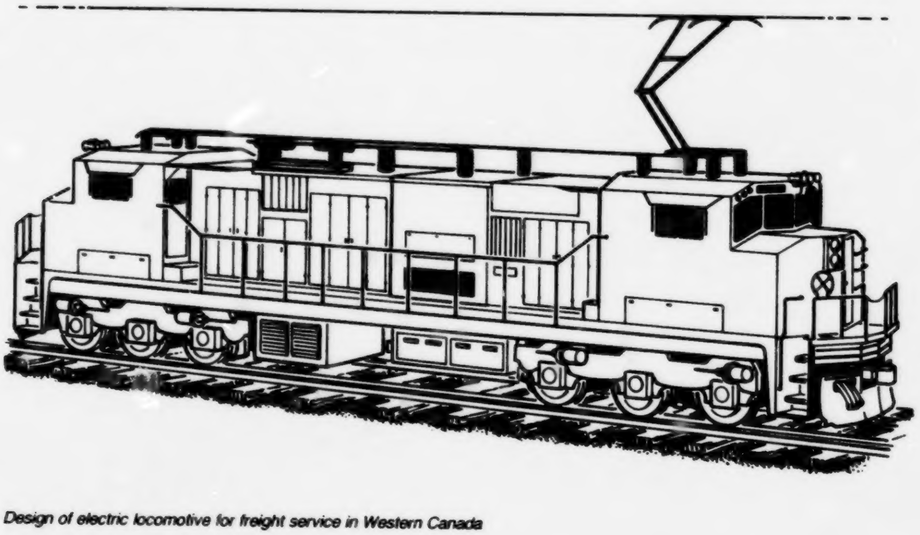
The conceptual design for an electric locomotive has been developed. Assembly drawings are now being prepared.

Contractor

Bombardier Inc., Montreal, Quebec

Report

None to date



Design of electric locomotive for freight service in Western Canada

Schedule: May 1983 — March 1985
Funding: Transport Canada Energy

Program —	$132,000
Bombardier Inc. —	$ 43,000
Total —	$175,000

Project Number: 6023
File Number: D-1465-402-2
Project Officer: C. Alfred Versailles

Hybrid Locomotive Study

Description

This project is contributing towards introducing major electrified railway systems in Canada as well as improving the existing low-voltage systems. Conceptual designs are being developed for hybrid locomotives suitable for each of these applications.

Major electrified systems require high power in both the diesel and electric modes. In the electric mode, the hybrid locomotive would effectively deal with localized obstacles such as ruling grades and tunnels, the only sections of track that would need to be electrified. On the remainder of the line, the locomotive would operate on diesel power.

The second application, low-voltage electrification systems, calls for a hybrid locomotive with moderate power capabilities.

Hybrid locomotives offer several advantages for a railway considering electrification:

- return on investment is higher than is possible with complete electrification;
- power assignment flexibility is maintained; and
- yard and passing sidings do not have to be electrified.

Developing conceptual layouts for both low and high voltage hybrid locomotives will include:

- collecting detailed information on suitable applications;
- organizing potential applications according to common factors such as type and level of supply voltage, and diesel and electrical power required; and
- determining overall hardware solutions for each application group.

Once the conceptual layouts are designed, manufacturing requirements and cost estimates will be determined.

Progress to July 1984

This project has just started.

Contractor

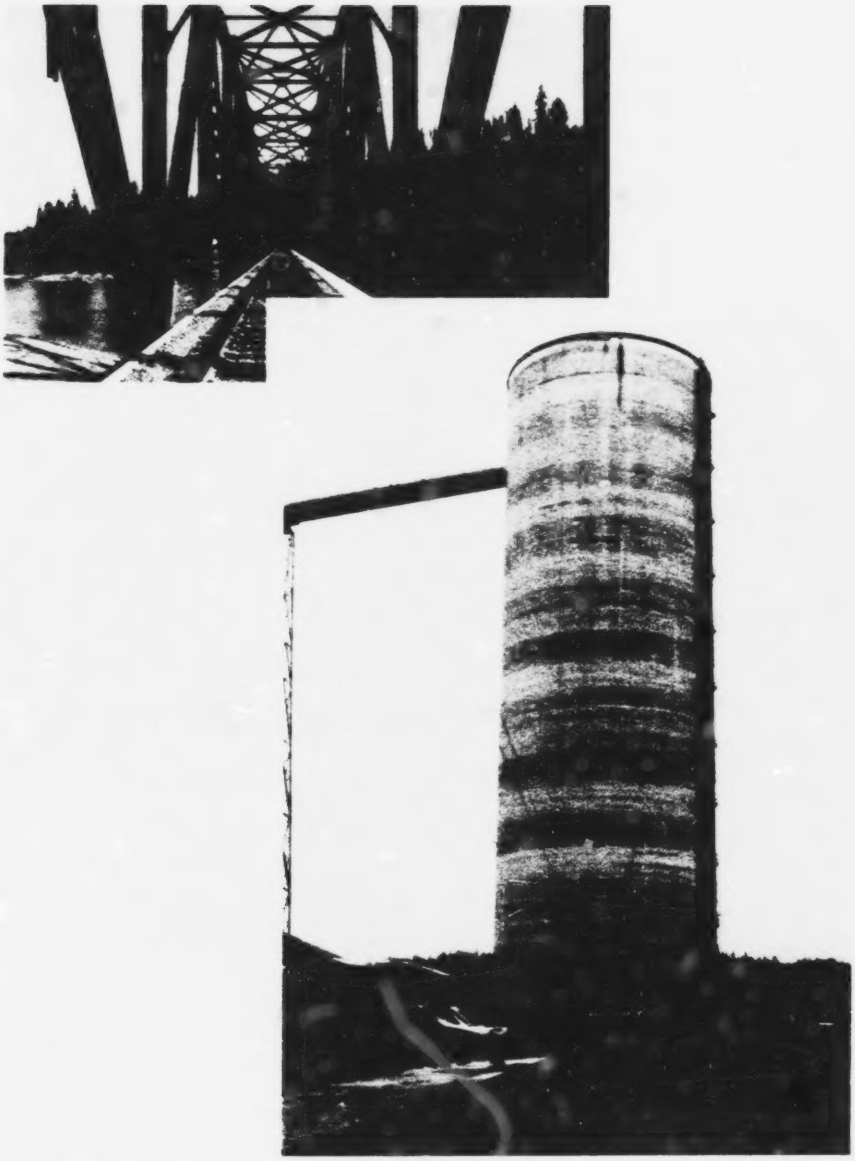
Bombardier Inc., Montreal, Quebec

Report

None to date

Schedule: May 1984 — January 1986
Funding: Transport Canada Energy Program — $110,000

Project Number: 6134
File Number: D-1465-429
Project Officer: C. Alfred Versailles



Two structures with clearance for 50 kV electrified rail operation: a truss bridge and a coal loading facility

Clearance Testing for 50 kV Operation

Description

Electrification of Canadian railways at 50 kV presents some problems with respect to electrical clearance on rail lines that pass under bridges and overpasses and through tunnels. In most cases, the existing clearances between these structures and the rail do not allow for standard clearances between the catenary (current carrier) and the tunnel roofs, undersides of bridges and underpasses, etc. Road salt, moisture, diesel exhaust, and other pollutants could aggravate the clearance problems.

Therefore, in order to better assess the technical problems and the probable cost and benefits of railway electrification in Canada, TDC recognized the necessity of determining the effect of various parameters on the electrical strength of air gaps. In turn, this would help establish a minimum non-standard clearance between the catenary and electrical ground for 50 kV railway operation.

Researchers used the unique high-voltage facilities available at the Institut de recherche d'Hydro-Québec to carry out a series of tests under various air conditions (e.g., clean, salt-water fog, and particle-contaminated). Tests included impulse, impulse with power frequency, and short duration power frequency on at least four clearances in each test. Other power frequency tests with critical rates of rise of 1 kV/s were also made. The most significant parameter was found to be diesel exhaust fumes, which produced up to 20% reductions in the 60 Hz strength of air gaps.

The results of this work will permit railways to use non-standard clearances in certain locations and thus avoid costly alternatives, such as lowering tunnel floors, raising bridges and overpasses, or even rebuilding complete bridges.

Progress to July 1984

This project has been completed.

Contractor

Canadian Electrical Association (CEA), Montreal, Quebec

Report

TP 5000E, Air clearances for 50 kV 60 Hz railway operations, Institut de recherche d'Hydro-Quebec, 1984.

Schedule: July 1982 — January 1984		**Project Number:** 4767
Funding: TDC —	$39,000	**File Number:** D-1465-317-11
CEA —	$39,000	**Project Officer:** C. Alfred Versailles
Total —	$78,000	

Switcher Locomotive Study

Description

In light of rising fuel costs, the fuel efficiency of the entire North American switcher fleet is considered to be far below standard. Locomotives now used for switching operations are of two types: outdated, low horsepower units (250 to 1500 hp) and older, general purpose locomotives. Neither type meets today's requirements for fuel efficiency or environmental protection.

The objectives of the current study were to establish the technical requirements and design of a diesel switcher locomotive suited to present and future service requirements, and to analyze costs and market potential in North America.

The design of the locomotive addresses the following basic principles:

- optimum tractive effort within the working speed range,
- maximum fuel efficiency under all operating conditions,
- compatability with environmental regulations,
- high reliability and easy maintenance, and
- low initial cost.

As far as is possible, the new switcher locomotive design is of modular construction, using existing components and sub-assemblies consistent with the design philosophy.

Progress to July 1984

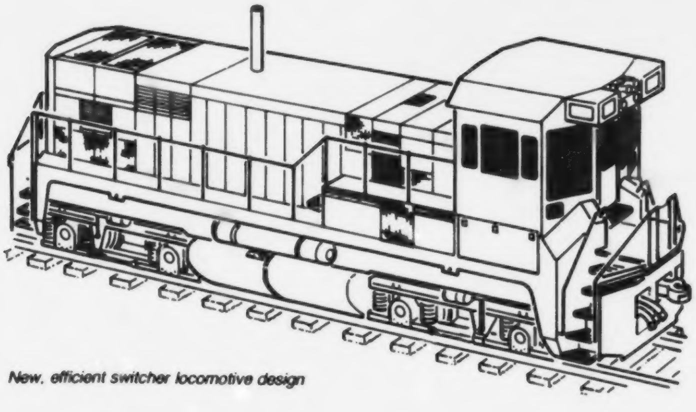
Technical work has been completed; a report is in preparation.

Contractor

Bombardier Inc., Montreal, Quebec

Report

Draft (TP 5732E), Switcher locomotive conceptual study, Bombardier Inc.



New, efficient switcher locomotive design

Schedule: June 1982 — October 1984

Funding: TDC-ARFP —	$ 59,600
Bombardier Inc. —	$ 59,600
Total —	$119,200

Project Number: 4586
File Number: D-1465-376
Project Officer: Roy S. Nishizaki

Stirling Cycle Locomotive Engine

Description

External combustion engines such as steam engines and Stirling cycle engines were widely used in the last century, but were subsequently displaced by internal combustion engines and the electric motor. Concern about possible future shortages of petroleum-based liquid fuels has resulted in renewed interest in Stirling cycle engines, since they can utilize heat generated in a variety of ways.

The Ringbom design uses relatively low pressure air as the working fluid and requires only one seal on the working piston rod, thus limiting the problem of seal leakage inherent in the Stirling cycle engine.

The objective of this project is to investigate the feasibility of developing Ringbom-Stirling engine technology for application as motive power units for railway locomotives. The generation of heat from coal burned in a fluidized bed combustion unit and transfer of the heat to the engine through sodium vapour heat pipes will also be studied.

Progress to July 1984

As a first phase of the project, an experimental Ringbom-Stirling engine has been built. The heater, generator, cooler, and Ringbom free displacer units have been designed and fabricated to match an engine rating of approximately 17 bhp. Initial engine trials have been conducted, and analysis of performance data is underway.

Contractor

University of Calgary, Calgary, Alberta

Report

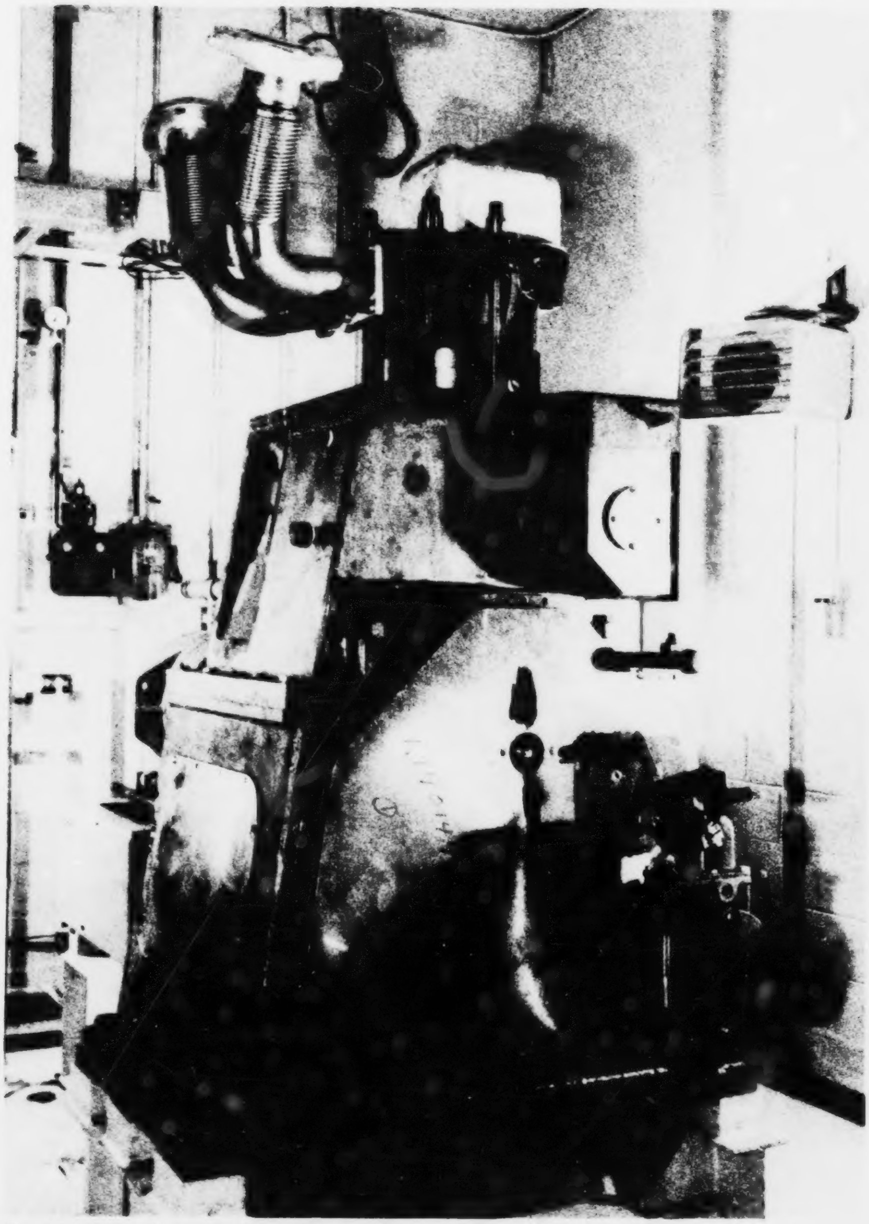
None to date

Heater unit for Stirling cycle locomotive engine

Schedule: November 1981 — April 1985
Funding: Transport Canada Energy

Program —	$240,000
DSS —	$160,000
Total —	$400,000

Project Number: 4427
File Number: D-1465-345
Project Officer: N.R. Gore



One of two Bombardier single-cylinder research engines

Medium-Speed Diesel Combustion Research

Description

Because the design of a diesel engine is greatly influenced by the fuel it burns, research on the combustion phenomena of diesel engines is particularly important. This project has made significant advances in determining the combustion efficiency of a diesel engine when burning off-specification fuels.

Researchers began by designing two single-cylinder diesel engines. They then turned their attention to designing the related test facilities, including all ancillary equipment. This involved determining flow rates, pressures, heat transfer requirements, and other operating characteristics.

The third phase of this project will concentrate on bringing the test facility to operational status. The engines will be qualified by a series of research tests, and correlation factors will be developed based on the test results and existing multi-cylinder performance data.

Tasks planned to realize Phase III include:

- installing an independent air supply system;
- measuring the performance of all critical engine components;
- operating the engines, monitoring performance parameters, and implementing modifications as required to qualify engines for tests; and
- analyzing single-cylinder and multi-cylinder results to develop correlation factors.

Progress to July 1984

Phase III of this project is being negotiated.

Contractor

Bombardier Inc., Montreal, Quebec

Report

TP 4844E, Design of a single-cylinder medium-speed research engine and test facility, Bombardier Inc., 1983.

Schedule: November 1982 — March 1986

Funding: TDC-ARFP —	$ 503,500
Transport Canada Energy Program —	$ 937,900
Bombardier Inc. —	$ 335,400
Total —	$1,776,800

Project Numbers: 4558, 4833, 4840, 6303-4
File Number: D-1465-372-2
Project Officer: Roy S. Nishizaki

Microprocessor Control of Locomotive Propulsion Electronics

Description

Since 1975, TDC has been supporting the development of a.c. locomotive propulsion which, by achieving 1000 hp per axle, would significantly improve the performance of Canadian diesel-electric freight locomotives. However, the ongoing development of a.c. propulsion has identified several problems requiring research. The principal area of concern is a.c.-d.c.-a.c. control electronics. Direct transfer of existing European technology for Canadian application is not possible because of dissimilar equipment configurations, bulky components, and different operating practices.

Consequently, the objective of this project is to develop a microprocessor-based controller for an a.c.-d.c.-a.c. power control unit, and to test the system in operational service on diesel-electric locomotives. A major advantage of a microprocessor-based control system is its flexibility to accommodate design changes during the development process. It also offers the benefits of reduced size, weight, and cost of electronics. Another asset of the microprocessor is its capacity for automatic fault diagnosis, which could simplify maintenance and repair procedures.

Successful completion of this project will significantly improve the attractiveness of a.c. propulsion for Canadian railways, and accelerate its introduction into service.

Progress to July 1984

Researchers at the University of Toronto have defined the software requirements for the microprocessor control system.

Contractor

BBC Brown Boveri Canada Inc., Pointe Claire, Quebec

Subcontractor

University of Toronto, Department of Electrical Engineering, Toronto, Ontario

Report

None to date

Schedule: March 1982 — June 1985		**Project Number:** 4560
Funding: TDC-ARFP —	$482,000	**File Number:** D-1465-371
BBC Brown Boveri Canada Inc. —	$252,000	**Project Officer:** C. Alfred Versailles
Total —	$734,000	

Two-Axle Locomotive Steerable Truck

Description

A steerable locomotive truck offers considerably improved performance over the standard truck in several areas, including stability and traction adhesion on curves. Introductory application of steerable trucks to rail vehicles is already underway in North America, but this work has been limited to freight cars and transit vehicles.

In 1980, TDC helped to sponsor a study by Canadair Services Ltd. into the use of steerable axle trucks for freight locomotives, a study which concluded that the concept was technically feasible, but costs and benefits should be investigated. Based on its own operations, CN Rail undertook a cost/benefit analysis and concluded that retrofitting locomotives with steerable trucks was not economical at that time, but that the concept could apply to a new locomotive.

More recent studies by Bombardier have shown that it may be possible to produce a steerable truck for about the same price as a standard truck. Two designs were identified as suitable candidates: a radial arm steerable truck (List principle) and a rigid frame Flextruck (Bombardier design).

In this project, Bombardier researchers have furthered their study of the two designs. They began by defining detailed evaluation criteria and techniques. Then, using a 0-weight transfer truck as a reference vehicle, they developed computer simulation models to compare the performance, practicality, and cost of the two designs.

Progress to July 1984

The technical work has been completed; results of the study and recommendations are in preparation. The most promising of the two trucks will be advanced to detailed design.

Contractor

Bombardier Inc., Montreal, Quebec

Subcontractor

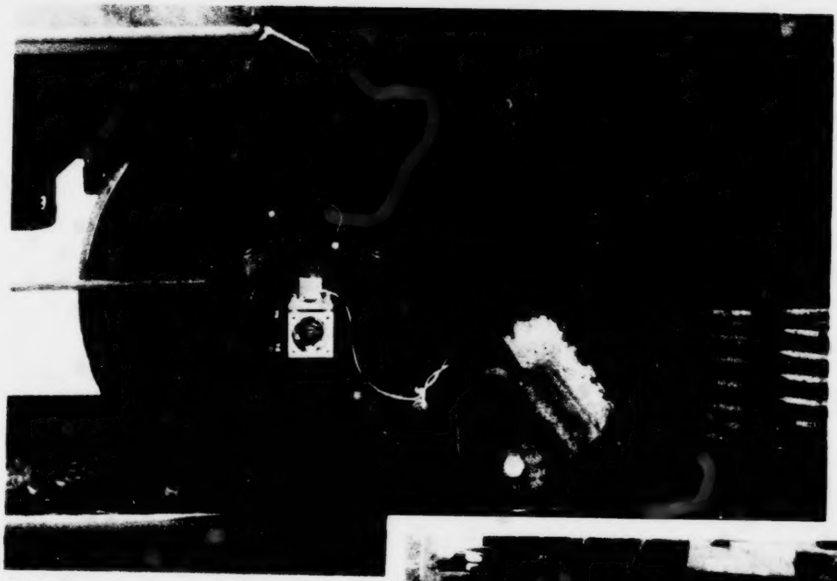
DSL Dynamic Sciences Ltd., St. Laurent, Quebec

Report

Draft (TP 5959E), Study to determine the most feasible design for a two-axle steerable locomotive truck, Bombardier Inc.

Schedule: April 1982 — November 1984
Funding: TDC — $320,000

Project Number: 4715
File Number: D-1465-290-2
Project Officer: C. Alfred Versailles



Instrumentation monitoring stability and wheel wear on frame-braced truck

Gondola car with retrofitted frame-braced truck

Frame-Braced Freight Car Truck Development

Description

The objective of this project is to determine the potential of the frame-braced truck as an alternative to the recently developed cross-braced steerable truck.

Standard three-piece freight car trucks suffer from design deficiencies that prevent satisfactory curving performance without excessive wheel flange forces. They are also vulnerable to hunting (lateral instability) in lightly loaded cars travelling faster than 80 km/h. The shortcomings cause accelerated rail and wheel wear, higher fuel consumption, and increased track gauge and alignment problems. The hunting results in operational limitations as well as lading damage and accelerated deterioration of truck components.

Recently developed steerable trucks, using cross-braced techniques, permit the wheelset to align itself radially with the curve. This decreases the angle of attack between the vertical plane of the wheel and the rail, thus correcting the curving deficiencies found in the standard trucks.

The frame-braced concept provides similar benefits to steerable trucks, but is simpler and less costly. Preliminary low-speed curving tests, performed at the National Research Council, verified the performance predicted in a theoretical analysis conducted by the Urban Transportation Development Corporation.

The current project compares the stability and wheel wear of the frame-braced truck with that of the standard three-piece truck. Two standard freight cars have been retrofitted to frame-braced design. The retrofitted and standard trucks have been installed on four gondola cars, instrumented and run in a series of tests on track owned and operated by the Ontario Northland Transportation Commission.

Computer modelling, which assisted in the design phase of the project, will also be used to assist in economic projections.

Progress to July 1984

Two standard cars retrofitted to frame-braced design have been in service since the summer of 1983. They have been tested for hunting and curving performance. To date the cars have run for more than 15,000 km. Collection of data continues.

Contractor

Urban Transportation Development Corporation, Kingston, Ontario

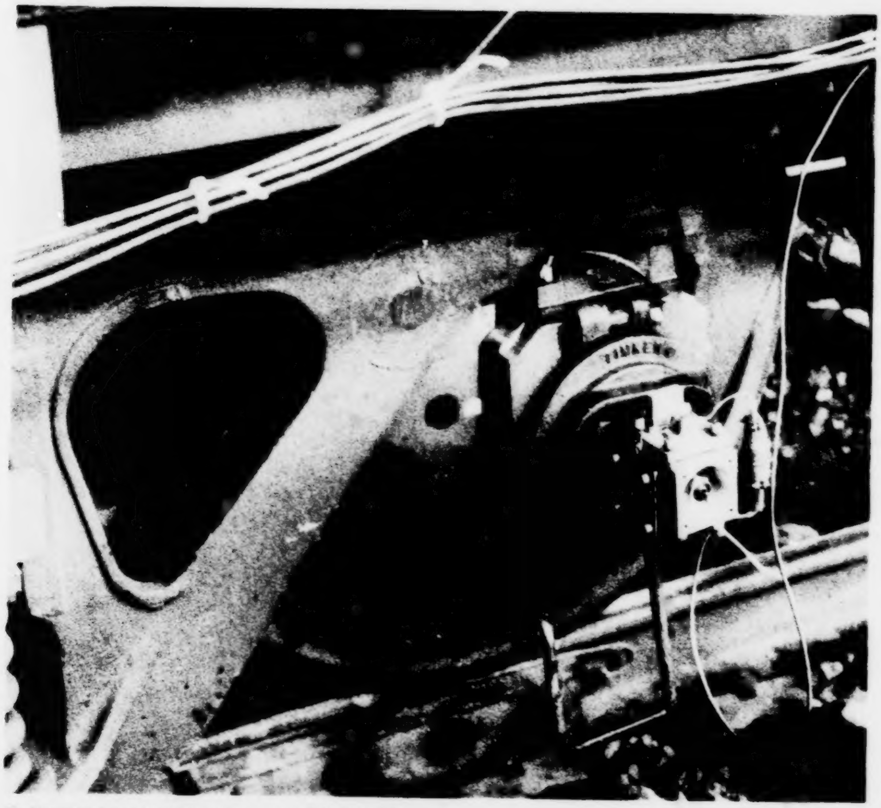
Report

TP 4869E, Axle angle of attack comparison: frame-braced vs conventional freight truck, Urban Transportation Development Corporation, 1983.

Schedule: November 1982 — April 1985

Funding: TDC-ARFP —	$104,000
Ontario Ministry of Transportation & Communications —	$ 46,250
Ontario Ministry of Northern Affairs —	$ 50,000
Total —	$200,250

Project Number: 4729
File Number: D-1465-384
Project Officer: Doug W. Dibble



Profilometer measuring wheel wear on radial axle trucks

In-Service Evaluation of Radial Axle Trucks

Description

The aim of this project is to obtain quantitative engineering data on the comparative performance of conventional and radial axle freight car trucks, particularly with respect to wheel wear.

In the late 1970s, CP Rail tested five radial trucks, of which two, the DR-1 and the Barber Scheffel, were found to be most effective for reducing lateral curving forces and angle of attack while maintaining stability at high speeds. Angle of attack indicates the degree of wheel rail misalignment, and thus of the contact surface between wheel and rail, a main factor in the wear process of both.

Field tests on the DR-1 were delayed until an initial incompatibility between the DR-1 truck and the brake system used on the CP Rail trucks was overcome through design modifications; the result is a modified truck, the DR-2.

Researchers are conducting in-service tests to measure wheel wear on a minimum of five test cars each of the DR-2, Barber Scheffel, and conventional Barber S2-C design. They also are testing elasto-cushion, rigidized elasto-cushion, and frame-braced trucks to determine wheel wear, hunting, and curving performance.

The test cars are equipped with modified Heumann profile wheels; the profile is measured with a specially-designed profilometer. The results of these tests will give CP Rail enough data to make a preliminary evaluation of these trucks for possible future use.

Progress to July 1984

After 320,000 km, preliminary wheel wear measurements show that the average flange wear experienced by Barber Scheffel truck wheels is less than one-fifth that of conventional Barber S2-C truck wheels. A modified design for DR-2 steering arms is complete, with retrofitted trucks scheduled for in-service testing. Preliminary results indicate that wheel wear on elasto-cushion trucks is similar to that on other premium radial trucks. Initial results comparing rigidized elasto-cushion trucks with conventional trucks showed improved performance on curving tests but poorer performance on hunting tests. As a result, the rigidized elasto-cushion trucks will be modified and retested. Testing for stability and curving performance on the frame-braced trucks is yet to be carried out.

Contractor

Canadian Pacific Limited, Montreal, Quebec

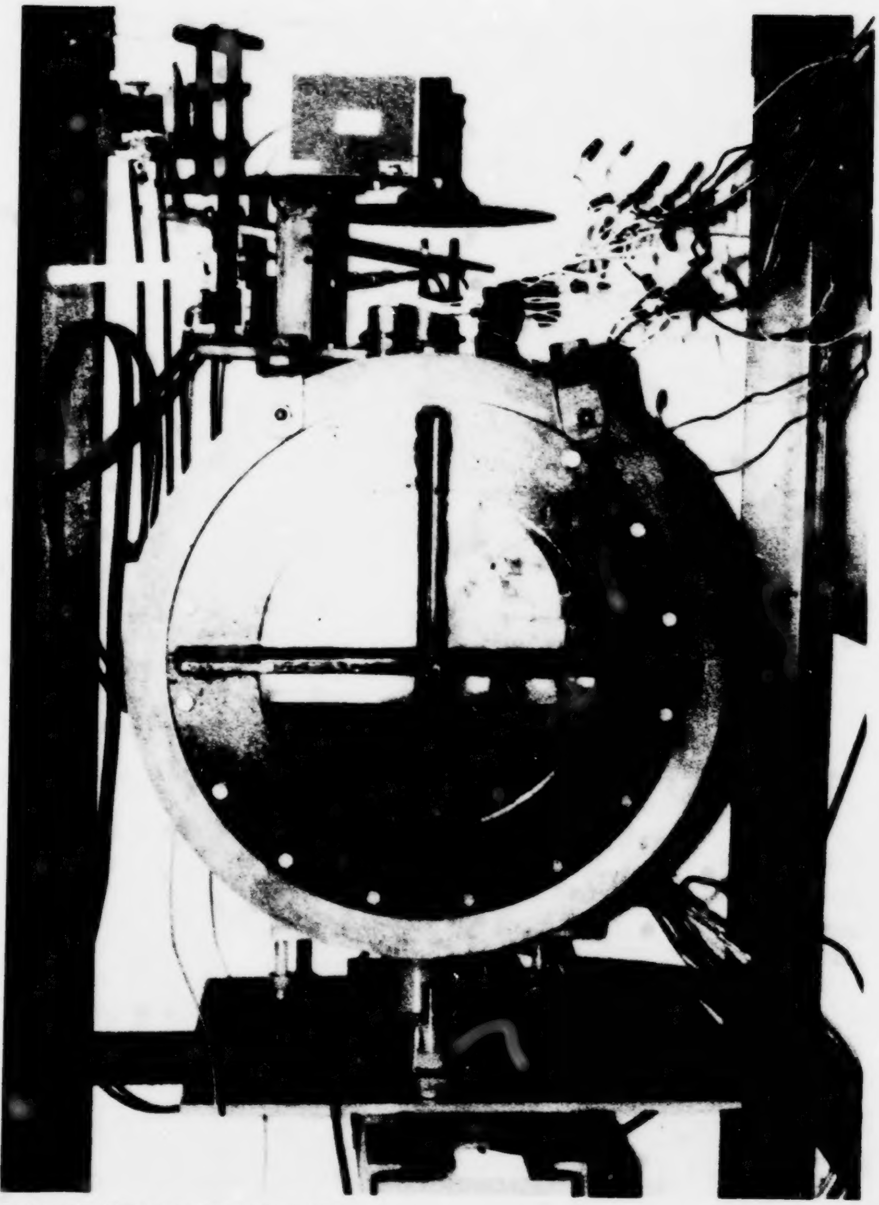
Reports

TP 5271E, Radial axle truck tests, vol. 1, Canadian Pacific Limited, 1983.

TP 5477E, Hunting and curving performance of rigidized elasto-cushion trucks, Canadian Pacific Limited, 1984.

Schedule: January 1984 — December 1984
Funding: TDC-ARFP — $131,000
CP Rail — $131,000
Total — $262,000

Project Number: 6132
File Number: D-1465-108-11-2
Project Officer: Doug W. Dibble



Tank car simulator for the study of thermal response

Tank Car Thermal Response Study

Description

The risk of explosions involving rail and road tank cars has escalated with the increased use of these cars for transporting liquified petroleum gas (LPG). The major hazard to public safety and the risk of destruction of property arises from boiling liquid/expanding vapour explosions. The main problem after collision or derailment is the build-up of wall temperature. Left unchecked, this build-up will weaken the tank structure and lead to rupture and explosion.

Researchers at the University of New Brunswick (UNB), Fire Science Centre, have been investigating alternatives to reduce the incidence and effect of these explosions. The test structure, constructed during the first stage of this project, is a cylindrical tank with plexiglass end walls. This facility allows for data collection and visual observation of the liquid and vapour phases created by simulated fire conditions.

One of the alternatives studied was Explosafe, an aluminum mesh explosion suppressant. It was concluded, however, that the costs and problems associated with the installation and cleaning of Explosafe were too great to justify further research.

Other experiments at the test facility included:

a) evaluation of heat transfer coefficients in the tank vapour space;
b) investigation of liquid behaviour with heat addition and pressure release;
c) the study of alternative internal tank protection methods; and
d) laboratory small-scale pool fire tests measuring the extra thermal load on the tank car wall generated by a propane flare.

Initial test results have revealed, among other things, that elements having the most profound effect on tank behaviour are: subcooling as a result of thermal stratification, length of pressure and temperature response of the pressure valve release, and boiling and swelling phenomena. The UNB study is expected to expand the knowledge of extended-surface heat transfer in boiling liquids, with possible industrial application.

Progress to July 1984

Experiments (a) and (b) have been run in the test tank, with and without Explosafe, using Refrigerant 11 (R11) to simulate the liquified petroleum gas. After conducting (c) with R11, experiments (a), (b), and (c) will be repeated using R12. The small-scale pool fire tests are also still to come.

Contractor

University of New Brunswick, Fredericton, New Brunswick

Report

None to date

Schedule: August 1982 — December 1984
Funding: Transport Canada Energy
Program — $171,000

Project Number: 4727
File Number: D-1465-302-6-4
Project Officer: Doug W. Dibble

Train Dynamics Simulation

Description

North American railways are meeting the need for higher operating efficiency through the design of new equipment and the development of new operating practices. In the area of equipment, major efforts are being directed to reducing vehicle tare weight, aerodynamic drag, and rolling resistance. On the operational side, new train handling techniques, such as the use of dynamic braking, are being implemented. These variations, directed at cutting fuel costs, create new operating conditions that may generate high in-train forces. Clearly, the railway must evaluate the consequences of equipment or operating changes before significant numbers of new vehicles are placed in service, or new train handling techniques are fully implemented.

In this project, researchers are designing a train action model to simulate, in real time, the operation of railway trains. A VAX 11/780 computer and a computer terminal will be used for the central control and operation of the simulation. Software, a user's manual, and other support documentation are also being developed. This simulation program will enable operators to determine the longitudinal acceleration of cars within the train.

Progress to July 1984

The longitudinal train action model has been successfully installed on the VAX 11/780 computer. Developmental work is continuing on sub-models, including the locomotive and air brake system. Progress has also been made on implementing the track profile display.

Contractor

DSL Dynamic Sciences Ltd., St. Laurent, Quebec

Report

None to date

Schedule: April 1983 — August 1985
Funding: TDC-ARFP — $377,000

Project Number: 4813
File Number: D-1465-108-12
Project Officer: Doug W. Dibble

Train Data Recording System Evaluation

Description

The objective of this project is to determine the suitability, through field tests, of various train data recording systems (TDRS) for Canadian locomotives.

The use of the TDRS (or locomotive event recorder, as some are called) for accident investigation has aroused considerable interest. Train data recorders would significantly assist the Canadian Transport Commission with its investigations, because the recorded information would reduce reliance on human memory and thus help to identify the causes of accidents.

To date there has been little operating experience with these recorders in Canada. This project will help determine the required characteristics of such a recorder and develop a data management strategy. The field tests will generate maintenance and reliability data. As the evaluation proceeds and experience is gained with recorders, the application of the data for training crew will be investigated.

Based on specifications prepared by TDC, CN Rail and CP Rail are conducting field trials of two recorders already available on the market: the Pulse Train Sentry and the Hasler Event Recorder. Each field trial includes performance tests, accident simulation tests, and analysis of reliability and maintenance characteristics.

Progress to July 1984

CN Rail studied the Pulse recorders in performance tests and accident simulations. Data have not yet been analyzed in detail, but the recorded information seems to be accurate. CP Rail is testing the Hasler recorder, and has installed the recorders to monitor reliability and maintenance.

Contractors

Canadian National Railway, Montreal, Quebec
Canadian Pacific Rail, Montreal, Quebec

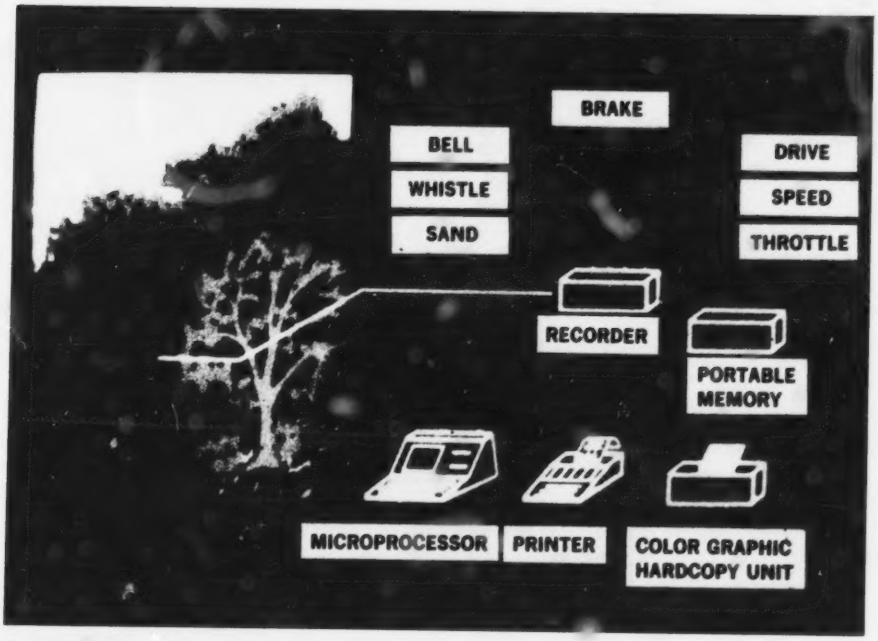
Report

None to date

Schedule: March 1983 — February 1985
Funding: Transport Canada Energy

Program —	$123,000
CN Rail — (in kind)	$ 25,000
CP Rail — (in kind)	$ 25,000
Total —	$173,000

Project Numbers: 4746, 4899
File Numbers: D-1465-390-3, D-1465-390-4
Project Officer: Doug W. Dibble


BRAKE
BELL
WHISTLE
SAND
DRIVE
SPEED
THROTTLE
RECORDER
PORTABLE MEMORY
MICROPROCESSOR
PRINTER
COLOR GRAPHIC HARDCOPY UNIT

Components of train data recording system

Train Data Recording System Development

Description

Conditions in the cab of the locomotive are not very friendly to sensitive recording equipment. Existing train data recorders using magnetic tape frequently suffer mechanical failures due to such factors as heat, cold, humidity, and incessant vibration. Yet Canadian railways need a rugged, reliable, and economical train data recording system capable of logging 20 or more parameters continuously for two or more days.

Therefore, the objective of this research is to develop an innovative train data recording system using solid-state microprocessor technology. The proposed system would employ a recorder mounted in the locomotive; an optional video display unit for the engineman; a playback unit with a keyboard, colour monitor, twin disk drive controller, and printer in a fixed location; and a portable memory transfer unit.

The current work involves five phases:

- design and fabrication of one breadboard prototype of each unit, with limited field testing on a CP Rail locomotive;
- design and fabrication of six prototype recording units;
- laboratory evaluation and a field test of one unit by CP Rail for one year;
- modifications to prototype units, based on lab and field tests; and
- extended testing of five recording systems by CP Rail, CN Rail, and VIA Rail over a minimum of six months.

Once environmental and vibrational tests have ensured that the design meets the operational requirements of the railway, a final design package will be prepared for mass production.

Progress to July 1984

Now that the design and fabrication of prototype units is complete, lab and field tests have identified a number of problems, including insufficient electrical protection from transient voltage spikes, loss of memory (RAM) due to power drainage during cold weather starting, sensitivity to humidity, and awkward handling of the portable memory unit. These problems are being addressed in the modification phase. Five recorders will be upgraded and installed in locomotives for further field evaluation, with software enhancements being made progressively.

Contractors

MPB Technologies Inc., Montreal, Canada
Warnock Hersey Professional Services Ltd., Toronto, Ontario

Reports

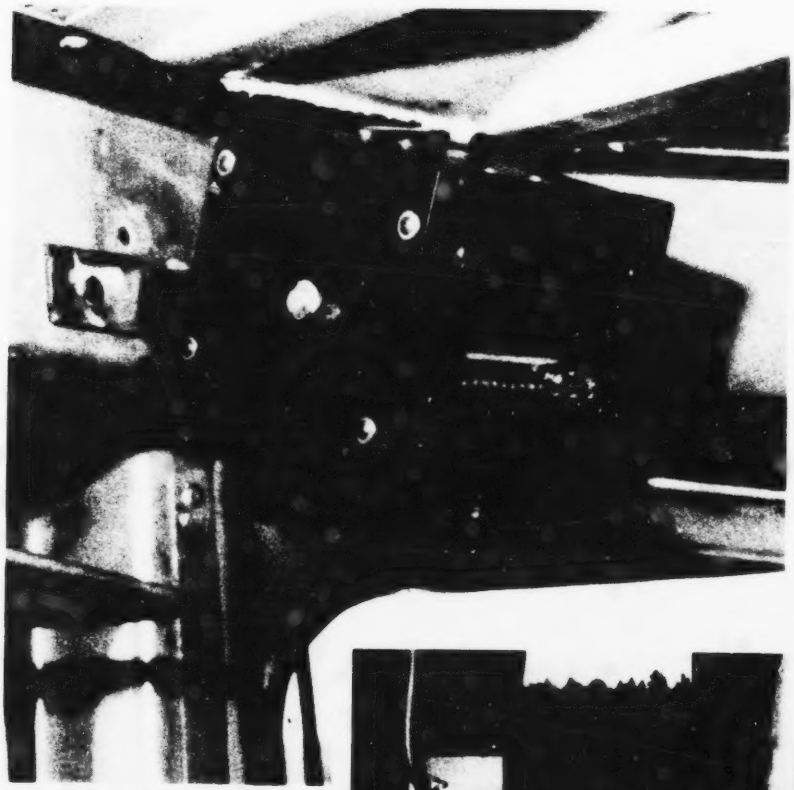
Draft (TP 3965E), Train data recording system, user's manual, MPB Technologies Inc.

TP 5105E, Train data recording system, MPB Technologies Inc., 1984.

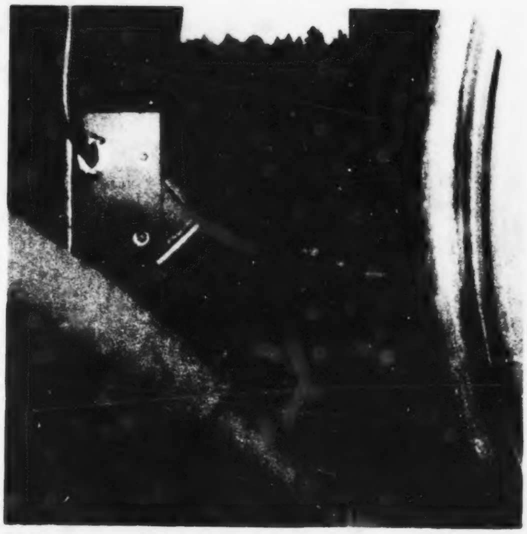
Schedule: October 1981 — September 1985

Funding: TDC-ARFP —	$286,300
Transport Canada Energy Program —	$121,400
DSS —	$131,300
CP Rail, CN Rail, & VIA Rail — (in kind)	$ 70,000
MPB Technologies Inc. — (in kind)	$ 70,000
Total —	$679,000

Project Numbers: 4462-3, 4800, 4983, 6109, 6306-7
File Numbers: D-1465-357, D-1465-390-2
Project Officers: Wayne G. Rowan, Doug W. Dibble



Cab-installed speedometer



Radar sensor component of speedometer

Locomotive Speedometer Evaluation

Description

Safety and operational considerations demand that the speed of passenger and freight locomotives be measured accurately, so that speeds do not exceed the crossing signal circuits for which they are set, and damage caused by high-speed shunting operations is avoided.

The purpose of this project is to provide Canadian locomotives with speedometers whose operation is not sensitive to wheel wear or to slippage between the rail and wheel, under traction or in braking operations. In a previous project, a radar speedometer produced by CMI of Colorado was identified as being most suitable for this purpose.

Twelve CMI radar speedometers are being evaluated in the field. They were installed on two classes of CN locomotives operating in three geographical regions: the Atlantic Provinces, Central Canada, and Western Canada. The speedometers are being monitored over a minimum period of two years.

Initial work included a short-term controlled test to evaluate the performance of the speedometers over water, ice, and open trestles, and at low speeds. If test results are satisfactory, further work may be done to incorporate the speedometer signal into a wheel-slip control device.

Progress to July 1984

The short-term tests, which were completed in February 1984, did not reveal any problems. However, some difficulties with the speedometer indicators have turned up during the long-term monitoring program. These indicators have been returned to the manufacturer for repairs. Long-term monitoring will continue.

Contractor

Canadian National Railway, Montreal, Quebec

Report

None to date

Schedule: December 1983 — December 1985
Funding: TDC-ARFP — $40,000

Project Number: 4530
File Number: D-1465-285-9
Project Officer: Doug W. Dibble

End-of-Train Monitoring

Description

Railways in both Canada and the U.S. are very interested in end-of-train monitoring equipment as a means to improve train safety and train handling from an energy conservation standpoint. The monitoring system would also eliminate the need for end-of-train crew, leading to improved operating efficiency. Such equipment may be required in the future by the Canadian Transport Commission. Recognizing this, TDC is supporting the design and development of an end-of-train monitoring system that will provide an automatic display of data in the locomotive cab.

After developing and testing a system to monitor such end-of-train conditions as brake line pressure, motion, clearance of switches, and draft forces, the contractor will modify software and hardware to comply with communications protocol established by the Association of American Railroads (AAR). Subsequently, an interface will be developed to utilize the monitoring device on railroads using either regular or air train lines for retarder braking. The contractor will also study the possibility of optimizing antenna systems for radio transmission and reception of data on trains without a caboose. Finally, the software will be revised to incorporate test and diagnostic facilities for the monitoring system.

Progress to July 1984

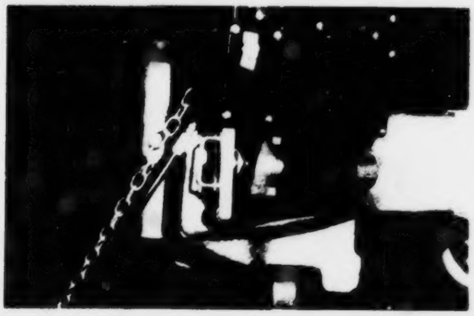
Design was completed for an end-of-train monitoring system capable of displaying brake line pressure. Four sets of this prototype end-of-train monitoring system have been constructed, each consisting of one rear unit and one front unit. Laboratory tests of the equipment were followed by a three-month evaluation in railway service. Design modifications are now underway to incorporate motion detectors, accelerometers, and hotbox detector readouts and to comply with AAR requirements. The modified system will be tested in spring 1985.

Contractor

Glenayre Electronics Ltd., Vancouver, British Columbia

Report

None to date



End-of-train monitoring system

Schedule: March 1983 — May 1985
Funding: TDC — $450,000

Project Numbers: 4924, 6271
File Number: D-1465-408
Project Officer: Micha Avni

Review of Signal Transmission Technology for Freight Trains

Description

Reliable train monitoring systems are necessary if major improvements in railway transportation are to be realized. These systems are needed at the locomotive and throughout the train, with head to tail transmission lines enabling on-board detection of overheated bearings and leakage in tank cars as well as monitoring of draft-gear forces and brake-pipe pressures.

The number of on-board signals is currently restricted because two-way radio systems have a limited spectrum and are susceptible to electromagnetic interference.

The Canadian Institute of Guided Ground Transport (CIGGT), sponsored by TDC, CP Rail and CN, has developed inductively coupled connectors that have proved to be rugged, reliable, and resistant to weather. But these connectors have limited power-handling and bandwidth capabilities and require separate air communications connectors.

Further research is necessary into alternative techniques for transmission of signals and power on freight trains to confirm or reject the use of inductively coupled connectors as the optimum technique. The combination of an air hose connector and an inductive connector into one air-electronic unit, for example, is being considered as a possible alternative.

This research study involved a technical review of a number of alternative new technologies. An extensive literature search as well as an investigation of relevant manufacturing concerns and R&D institutes was conducted. For each suitable transmission technique, the contractor examined such factors as the current state of development, operational and technical limitations, and compatibility with railway environments.

The study concluded that the only practical way of distributing power from the locomotive to the cars is by a two-wire transmission line. It also found that owing to its ability to carry both signals and power, a train-length transmission line is an effective communications link.

Progress to July 1984

Technical work has been completed; a report is in preparation.

Contractor

Queen's University, Canadian Institute of Guided Ground Transport, Kingston, Ontario

Report

Draft (TP 5704E), Review of signal and power transmission technology for freight trains, Queen's University, Canadian Institute of Guided Ground Transport.

Schedule: June 1983 — September 1984
Funding: TDC-ARFP — $23,250

Project Number: 6053
File Number: D-1465-158-2
Project Officer: Micha Avni

Rail Wear and Fatigue Model

Description

Some of the current research on railways is focusing on extending the operational life of rails. One area of this research is concentrating on the wear and fatigue on the wheel/rail system which can be attributed to heavily loaded cars.

This joint project of the Association of American Railroads and TDC is in its third phase and is concentrating on determining the effect of lubricants on the wear and fatigue process. The contractors, the National Research Council's Western Laboratory in Vancouver and the University of Rhode Island, are considering three sets of inter-related parameters: mechanical, metallurgical, and rheological. New wheel and rail disks are being run at different load levels and angle-of-attack settings under various lubrication regimes. Five different grease formulations are being used to determine the effect of grease additives. The results of this research will contribute towards developing a unified rail wear and fatigue theory, which will be useful in predicting rail life as well as determining efficient railway maintenance procedures.

A prototype tribometer, developed in an earlier phase, will be used experimentally to determine the distribution of creep coefficients between various wheel and rail materials. It was designed so that it also can be used during field tests to establish such parameters as the creepage/traction force relationship and the efficacy of trackside lubricators.

Progress to July 1984

The investigation of the effect of lubrication on the wear and fatigue process is proceeding according to schedule.

Contractor

National Research Council, Ottawa, Ontario

Report

TP 5346E, Establishment of quantitative wear and fatigue model for railway rail subjected to heavy traffic conditions and different lubrication regimes, October 1982 — September 1983 progress report, National Research Council, 1984.

Schedule: January 1984 — March 1985
Funding: TDC-ARFP — $ 65,000
NRC — $ 50,000
Total — $115,000

Project Number: 6155
File Number: D-1485-366-4
Project Officer: Doug W. Dibble

TDC/CP Cooperative Rail Research Program

Description

Since 1973, TDC and Canadian Pacific Limited have been working together towards achieving a greater understanding of the interaction between a train and its track in order to develop, operate, and maintain railway track and equipment. This increased knowledge will undoubtedly improve transportation productivity by ultimately improving the railway system.

This year's program is continuing the development of the witness groove, a technique to measure the wear on rails and wheels that occurs in a short time period. Other objectives of this year's research include:

- determining the factors responsible for wheel shelling;
- evaluating the wear performance of various types of rail from different countries;
- evaluating concrete slab track for tunnel installation;
- monitoring and evaluating several truck stabilizing devices, which will be used on a 70-ton trailer on flatcar (TOFC);
- developing a portable data logger; and
- identifying alternative angle-of-attack measuring systems.

Laboratory and field testing, along with computer modelling, are being used to meet these objectives.

Progress to July 1984

Surface residual stress measurements and microstructural analysis have been conducted on selected wheelsets for the investigation of wheel shelling. Wear measurements have been made on profiles of the Japanese alloy rail; the evaluation of other rail types is continuing. Forty piggyback cars were selected to test four different stabilizing devices. Periodic wheel profiles have been taken, along with visual inspection of critical components. The rail vehicle dynamic model is being validated for hunting and curving. Several alternatives for measuring angle of attack have been investigated. An LED-based system, which has several advantages over the current laser-based device, has been assembled and will be tested.

Contractor

Canadian Pacific Limited, Montreal, Quebec

Report

TP 5275E, Track/train dynamics, vol. 4, 1983, Canadian Pacific Ltd., 1984.

Track section instrumented to measure wheel wear

Schedule: January 1984 — December 1984

Funding: TDC — $181,000

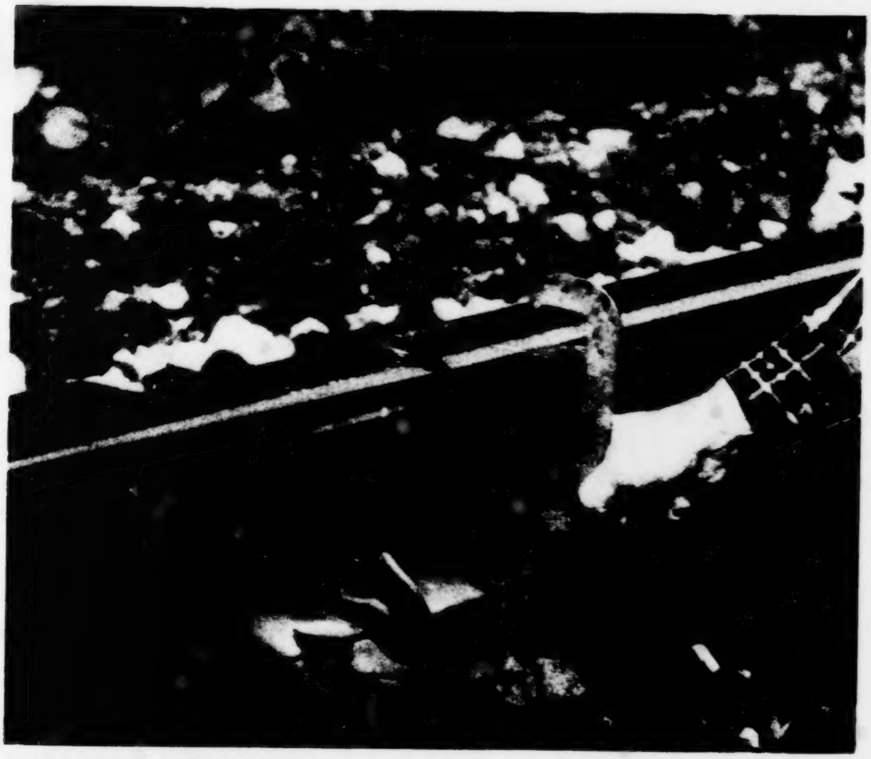
CP Ltd. — $181,000

Total — $362,000

Project Number: 6138

File Number: D-1465-403-3

Project Officer: Doug W. Dibble



Measuring asymmetrical ground rail profile

Rail Grinding Optimization

Description

TDC has been supporting research on developing a ground rail profile using conventional rail grinding equipment that will reduce rail corrugation, shelling, and side wear.

The first phase of this research included a number of field trials to gather the statistical data needed to analyze and formulate rail grinding specifications for optimum truck curving performance. This resulted in an asymmetrical ground rail profile design, which takes into consideration preventive maintenance techniques to extend rail life in curves, decrease wheel wear and fuel consumption, and reduce the frequency with which worn rail is ground.

The second stage of research will be validating this asymmetrical ground rail profile. Corrugation regrowth and rail wear on three test curves were monitored for a year, the equivalent of more than 50 million gross tons of heavy axle load traffic. A separate profile was designed for the high and the low rails. Grinding stone settings were established to provide a range of three profiles on each rail for two, four, and eight-degree curves. A total of fifteen curves were selected for validation tests, plus a set of three control curves, used for comparison. As a further test, recommended grinding techniques were compared with conventional techniques for CP Rail trackage on the Cascade and Thompson subdivisions in British Columbia.

Progress to July 1984

Twelve curves were ground to design profiles in May 1984. Monitoring will continue until the end of the year.

Contractor

Queen's University, Canadian Institute of Guided Ground Transport, Kingston, Ontario

Report

TP 3998E, Rail profile grinding, Queen's University, Canadian Institute of Guided Ground Transport, 1982.

Schedule: December 1981 — November 1984

Funding: TDC-ARFP —	$135,100
NRC — (in kind)	$ 6,000
CP Ltd. — (in kind)	$216,800
Railway Association of Canada —	$ 15,400
Speno Rail Services Co. — (in kind)	$ 9,900
Total —	$383,200

Project Numbers: 4562, 6011
File Number: D-1465-368
Project Officer: Wayne G. Rowan

Snowmaster — Conceptual Design

Description

Research completed in 1979 by the Railway Association of Canada found snow-removal equipment to be outdated and inadequate, and pointed to the need for new equipment for both terminal and mainline applications. This need becomes critical with the realization that no new equipment has been introduced for more than 30 years.

In line with these findings, this research project aimed at developing a conceptual design for a state-of-the-art snow-removal machine, the Snowmaster. The design takes into account regulatory and operational constraints.

In addition to its unique bi-directional capability, the self-contained Snowmaster provides crew accommodations in its cab. Other features that distinguish the Snowmaster from current equipment include its:

- snow-handling elements,
- chassis and trucks,
- turntable with drive system,
- flanging equipment,
- propulsion system options, and
- structural configuration of the body.

The Snowmaster offers Canadian manufacturers the potential of producing sophisticated equipment that will meet snow-removal requirements for the next 25 years.

Progress to July 1984

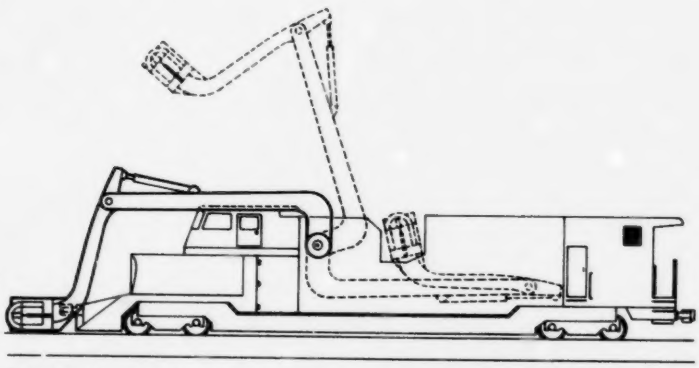
This project has been completed. Continuation of the research to the next phase, which would involve detailed component manufacturing and assembly drawings, will be contingent upon the railways' reaction to the initial design and the availability of suitable funding and contractual arrangements.

Contractor

Queen's University, Canadian Institute of Guided Ground Transport, Kingston, Ontario

Report

TP 5289E, Conceptual design of snow removal equipment for main tracks, Queen's University, Canadian Institute of Guided Ground Transport, 1984.



Design of bi-directional Snowmaster

Schedule: August 1983 — July 1984
Funding: TDC — $64,000

Project Number: 6038
File Number: D-1465-285-12-2
Project Officer: Wayne G. Rowan

Induction Track Hardening System

Description

Rail replacement is a major cost component in maintaining railway track. Steel costs alone are currently estimated at $300 million per year. Rail head hardening, which provides a greater resistance to wear, has the potential to considerably extend the life cycle of track.

This project involves laboratory investigations of a hardening technique using electrical induction heating, a method that is expected to produce high-quality hardened track.

The main objective of the treatment is to achieve a minimum surface hardness of 341 Brinell and a maximum of 388 Brinell, with a core hardness of 290 Brinell, and to extend hardening down the sides of the rail head to a depth of 1.9 centimetres.

If successful, this preliminary research may lead to a larger project: induction hardening at rail stringing plants, followed by the construction of a mobile track hardening unit for on-site use.

Progress to July 1984

Coil design is underway.

Contractor

Permatrack Inc., Vancouver, British Columbia

Report

None to date

Schedule: January 1984 — January 1985

Funding: TDC —	$20,000
DSS —	$26,000
Total —	$46,000

Project Numbers: 6136-7
File Number: D-1465-436
Project Officer: N.R. Gore

SIGNALLING,
COMMUNICATIONS
& CONTROL

Study of LIC Application on Mainline Track

Description

LIC is a radio-linked location, identification, and control system that provides dispatchers with continuous real-time monitoring of individual trains. The improved safety and increased line capacity that would result from successful LIC development for mainline use are of prime importance to Transport Canada. The objective of this study was to evaluate the feasability of the LIC system on mainline track in the national railway system.

TDC has participated in the development of LIC technology since 1975. In 1978, a small, experimental LIC system was put into trial operation in parallel with the manual control system. The success of this project led to the full-scale development and operational demonstration of LIC signalling on the Squamish subdivision of B.C. Rail in 1983.

The evaluated system did not incorporate all the features required for application to mainline railways, such as speed monitoring, remote brake activation, and remote control of switch points. Subsequently, further development work was undertaken to identify and design the additional signalling required for mainline railway operation and for certification by the Canadian Transport Commission.

In this first step to develop the LIC system for mainline application, the contractor carried out technical studies and a design analysis, and prepared the software for a data processor. To expand the system, the prototype data collection processor (DCP) was redesigned around a standard microprocessor bus system. Following this, the contractor prepared user specifications and a design for an LIC system on medium-density mainline track. It was concluded that although the LIC system is capable of expansion to meet mainline requirements, the large amount of engineering necessary precluded further development work until warranted by specific customer interest.

Progress to July 1984

This project has been completed.

Contractor

Glenayre Electronics Ltd., Vancouver, British Columbia

Reports

TP 5032E, Location, identification and control system application to mainline railroads, Glenayre Electronics Ltd., 1983.
TP 5217E, Location, identification and control system application to mainline railroads, summary report, Glenayre Electronics Ltd., 1983.

Schedule: March 1982 — April 1984
Funding: TDC-ARFP — $491,230

Project Number: 4510
File Number: D-1465-128
Project Officer: Micha Avni

Automatic Rail Car Identification System

Description

Railways need a highly reliable, accurate system of automatic rail car identification. By eliminating manual reading of labels on each car entering or departing a terminal, railways would realize substantial operating benefits. Other transportation operators, including bus and truck companies, would also benefit from the successful development of a practical automatic car identification system.

In the mid-1960s, the railways developed a standardized optical system for automatic car identification, but the system did not meet expected performance levels and was removed from service in 1977. However, as the need for such a system remains, TDC is supporting this project to design and test a passive rail car identification transponder, a field programming unit to set the car number in the transponder, and a controller/interrogator to read the transponder.

The contractor constructed a rotating rig to perform tests on a prototype transponder. No errors or misses were experienced in 21 million transponder passes at normal noise levels; while at high noise levels, there were no errors and only one miss for every million passes. The transponder electronics have been committed to an LSI (large-scale integration) chip.

Progress to July 1984

The project is "on hold" until system testing can be arranged with one of the major Canadian railroads.

Contractor

Glenayre Electronics Ltd., Vancouver, British Columbia

Report

None to date

Schedule: March 1982 — March 1985

Funding: TDC —	$250,000
DSS —	$170,000
Total —	$420,000

Project Numbers: 4436-7
File Number: D-1465-347
Project Officer: Micha Avni

Railway Colour Light Signal

Description

The development of a reliable passive single-lens railway colour signal is a priority in TDC's continuing research into new ways of improving safety, productivity, and efficiency of our national railways.

Searchlight signals on North American railways have one lamp and one lens, although the unit can display three different colours. A burnout of the lamp in this searchlight signal will result in an unlit signal, creating a potentially dangerous situation. Malfunction of other components is rare, although the potential is there, with consequent risk of improperly displayed signals. Trains approaching an unlit electric signal are required to come to a full stop, and may proceed only after specific safety procedures have been followed.

To overcome these shortcomings, TDC is collaborating with CN Rail in developing a new design for railway colour light signals. Emphasis will be on the design of a non-mechanical signal, with built-in protection against lamp burnout.

The design will include:

- retention of the single-lens feature of present railway searchlight signals;
- non-mechanical display of three colour changes;
- protection against lamp burnout by reserve lamps or other methods, combined with electric circuitry sensitive to "lamp out;" and
- automatic lighting of reserve lamps and an indication confirming that the final reserve lamp is lit.

Signal design and control will be in accordance with current standards set by the Association of American Railroads. Thus, this project, if successful, will provide an opportunity for a Canadian manufacturing firm not only to compete, but to have a clear advantage over established U.S. signal suppliers. It is estimated that Canadian railroads require more than 300 light signals every year.

Progress to July 1984

Preliminary electrical, optical, and mechanical designs of a solid-state railway signal light and an automatic lamp changer for existing searchlight signals have been completed. Two prototype lamp changers have been built and are undergoing functional tests. A complete laboratory evaluation will follow.

Contractors

Hovey & Associates (1979) Ltd., Ottawa, Ontario
Davis Engineering Ltd., Ottawa, Ontario

Report

None to date

Schedule: February 1983 — December 1985

Funding: TDC —	$155,100
CN Rail — (in kind)	$ 26,000
Total —	$181,100

Project Numbers: 4812, 4980
File Number: D-1465-378
Project Officer: Wayne G. Rowan

Railway Level Crossing Signals

Description

There are approximately 100 fatalities and 500 serious accidents each year at Canada's 24,000 rail/highway level crossings. Although these numbers are small when compared to total highway accident statistics, the problem warrants an attempt to find some means of improving, or providing alternatives to, the current warning signal system of flashing lights at railway level crossings without barriers. With the objective of reducing the number of rail/highway crossing accidents, this project studied the possibility of such improvements and alternatives.

Since 1978, TDC has supported studies aimed at improving rail/highway crossing safety. One study concluded that standard traffic signals showed promise of improved safety at level crossings. Although their use would require new developments in regulatory authority, definitions of legal liability, law enforcement practices, and maintenance procedures, they would be far less costly than advanced collision-avoidance/crossing-protection systems or full grade separations.

In this project, researchers examined accident studies to find out whether the current flashing signal system acted as a contributory factor in accidents, especially from the perspective of the highway driver. They also looked into system improvements to determine the pros and cons of having traffic signals at level crossings without barriers. After examining present standards on the use and installation of these systems, they solicited the views of railway companies and regulatory agencies.

The final report identified several problems associated with flashing light devices at crossings. Researchers noted that flashing lights often are not sufficiently conspicuous, but questioned the cost-effectiveness of improving their visibility. Another problem is that the apparent sudden onset of signals sometimes causes a panic reaction in drivers, a situation that might be improved by an activated advance warning signal. A more deep-seated difficulty is the public belief that flashers are not reliable, but this might be alleviated by using constant-warning-time devices. Although, in the past, the use of traffic signals has been proposed as a solution, the report concludes that their widespread use would be of dubious value, and it recommends instead that highway and railway authorities cooperate with equipment manufacturers to solve the problem.

Progress to July 1984

This project has been completed.

Contractor

University of Toronto, Department of Civil Engineering, Toronto, Ontario

Report

TP 5308E, Flashing lights and bells at grade crossings: present problems and directions for the future, Department of Civil Engineering, University of Toronto, 1984.

Schedule: April 1983 — July 1984
Funding: TDC — $14,500

Project Number: 4947
File Number: D-1465-405
Project Officer: Catherine Hirou

Railbus: Pilot Vehicle Development

Description

In many remote communities in northern Manitoba, as elsewhere in Canada, rail provides the sole means of ground transportation. But these small communities generate too limited a ridership to justify the costs of operating conventional, 80-passenger rail cars. Clearly, this type of equipment is inappropriate for these areas.

One proposed solution to this situation is a highway coach modified to run on rail tracks. The principal benefits of using a vehicle based on bus technology are its lower acquisition, operating, and maintenance costs as compared to current rail equipment.

The Canadian Transport Commission, the province of Manitoba, and the local community are interested in a demonstration of a "railbus" in northern Manitoba. As a first step, TDC is supporting the development and construction of a pilot railbus that will be used to explore the operational and safety issues involved in operating a non-conventional vehicle such as this.

An existing Flyer motor coach has been modified and equipped with steel wheels for operation on standard rail tracks. The suspension, brake system, drive train, and lights are among the components that have been modified. A hydraulic turntable will be added to allow the railbus to reverse direction.

Progress to July 1984

Initial tests of the railbus have been conducted successfully up to a speed of 60 km/h. Further tests on tangent and curved track will measure ride quality, maximum safe operating speed, and vehicle stability.

Contractor

Winnipeg Coach Sales and Service Ltd., Winnipeg, Manitoba

Report

None to date

Schedule: March 1984 — February 1985

Funding: TDC —	$ 31,300	**Project Number:** 6182
CSTA —	$114,200	**File Number:** D-1465-425
Total —	$145,500	**Project Officer:** Brian Marshall

Unsprung Mass Alternatives for the LRC

Description

The LRC, an advanced train concept currently in service with VIA Rail, is designed for 200 km/h operation. However, it has been restricted to 150 km/h service in accordance with criteria established by CN Rail. One of the problems lies in the LRC locomotive's high unsprung weight, due to axle suspension of the traction motor, which produces dynamic forces at rail joints that exceed CN Rail criteria.

In 1980, TDC commissioned a study that analyzed various methods of reducing wheel/rail impact forces. Based on information in that report, the objectives of this project were identified: to develop a computerized mathematical model for evaluating the effect of resiliency in the load path at the wheel, and to use this model to explore alternative means of suspending motors. Researchers hope to determine a cost-effective method of reducing wheel/rail impact forces that can be incorporated as a retrofit to existing LRC locomotives.

By promoting improvements to the current LRC locomotive design, TDC will help the train achieve its full operational potential in Canada and enhance its competitiveness in world markets.

Progress to July 1984

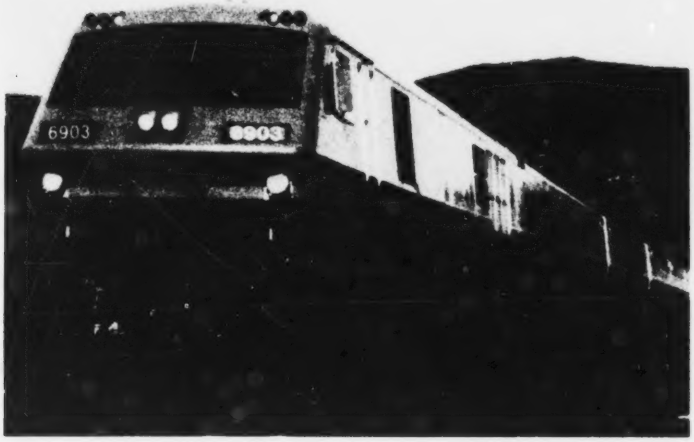
The mathematical model incorporating rail joint geometry and stiffness, unsprung weights, and motor suspension has been developed. The effect of resiliency at various points in the load path has been evaluated. The correlation of model results to actual acceleration measurements will follow.

Contractor

Bombardier Inc., Montreal, Quebec

Report

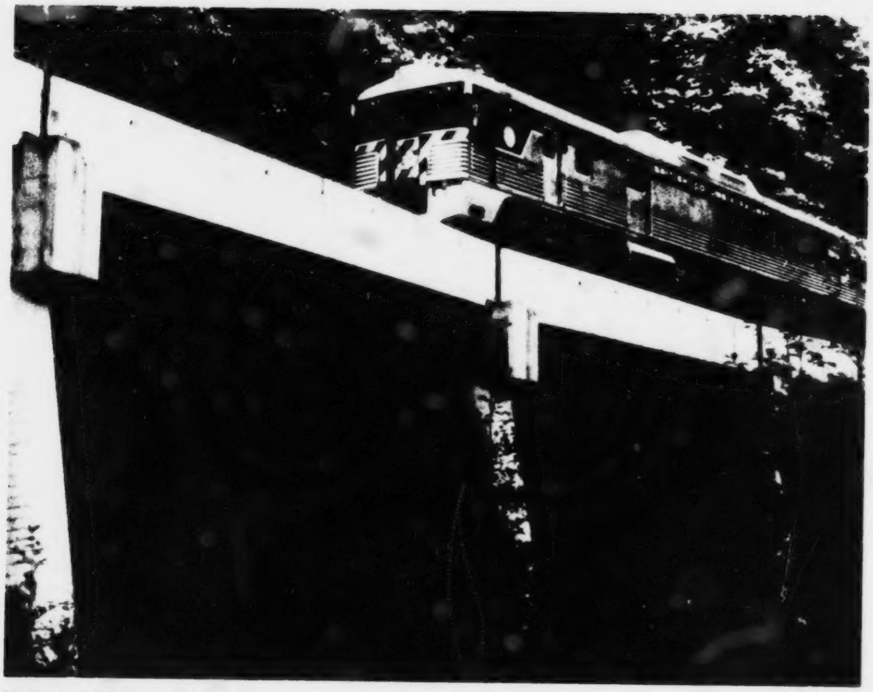
None to date



The LRC

Schedule: January 1983 — March 1985
Funding: TDC — $225,000

Project Number: 4771
File Number: D-1465-110-7
Project Officer: C. Alfred Versailles



Modernized RDC in operation

B.C. Rail RDC Evaluation

Description

Budd rail diesel cars (RDCs) have been part of Canadian railways' rolling stock for more than 25 years. They are self-propelled, combination passenger and baggage/express freight cars, with stainless steel bodies. They are powered by two obsolete General Motors 6-110 diesel engines.

TDC sponsored a feasibility study in the mid-1970s for the possible modernization of these deteriorating cars. A consortium, led by Canadian Pacific Consulting Services Ltd., produced a comprehensive report in December 1976, recommending guidelines for modernizing the interior, exterior, and propulsion of the RDCs. VIA Rail introduced a limited improvement program in 1979 for the replacement of the prime propulsion engines and interior refurbishing. In 1982, B.C. Rail contracted with Versatile-Vickers Inc. to rebuild one RDC almost completely. This converted car has been operating in regular B.C. Rail passenger service for a number of months and is under examination in this project.

Comparative field studies were conducted on the modernized RDC and an unmodified car, on two round trips between North Vancouver and Lillooet, during two different seasons. Their performance was compared on such factors as noise, vibration, temperature control, total power and fuel consumption, schedule adherence, and reliability measurements. In addition, passengers and crew were interviewed to assess the quality of ride, seating, and interior aesthetics as well as food service, galley convenience, and visibility, location, and operation of controls. The main elements of the modernized RDC, such as the propulsion system, galley, and driver's cab, were analyzed for cost effectiveness.

Public acceptance of the modernized RDC, BC-33, was excellent. B.C. Rail was generally satisfied with the performance and reliability and is continuing its modernization program with relatively few changes.

Progress to July 1984

This project has been completed.

Contractor

British Columbia Railway, Vancouver, British Columbia

Subcontractor

H.A. Simons (International) Ltd., Vancouver, British Columbia

Report

TP 5345E, B.C. Rail RDC prototype evaluation, H.A. Simons (International) Ltd., 1984.

Schedule: April 1983 — March 1984

Funding: TDC —	$30,000
B.C. Rail —	$30,000
Total —	$60,000

Project Number: 4981
File Number: D-1465-123-6
Project Officer: Wayne G. Rowan

Human Factors in Rail Passenger Car Design

Description

Rail passenger services, as well as other passenger transportation modes, often sacrifice comfort or health features for the sake of economics. This project addresses human factors as well as economic considerations needed to develop a comfortable, cost-effective railway passenger service.

Rolling stock currently used on transcontinental routes requires high maintenance and labour for its relatively low passenger density. The public demands that some of these services remain. As a result, railways are considering the purchase of new and more efficient long-distance cars offering a level of service and comfort suitable for passengers travelling in them over periods ranging from six hours to six days.

The first step in determining the optimum design of such a car for the Canadian market requires the following:

- a detailed literature search of relevant ergonomic and psychological knowledge;
- analyses of national and international passenger accommodations over a wide range of vehicles; and
- a review of consumer attitudes towards accommodations offered in different transportation modes.

Recognizing the need for such information, TDC supported this project in its objectives to synthesize existing information, to develop research questions that will fill the gaps in the existing literature, and to document the results on the feasibility of comfortable, cost-effective railway passenger accommodation.

Aside from researching rail passenger cars, the project also drew from data on cruise ships, travel trailers, sailboats, the bed-in-a-drawer, Japanese sleeping capsules, and submarines. The efficient use of interior space was studied in light of passengers' requirements, both physical and psychological. A number of other factors were considered, including: the requirements of air and lighting, the effects of noise, the orientation of sleeping relative to vehicle motion, and the degree of privacy offered by washrooms and sleeping compartments.

Progress to July 1984

This project has been completed.

Contractor

Behavioural Team, Toronto, Ontario

Report

TP 5488E, Human factors in rail passenger car design, Behavioural Team, 1984.

Schedule: April 1983 — August 1984
Funding: TDC — $33,333
VIA Rail — $16,667
Total — $50,000

Project Number: 4816
File Number: D-1465-389-2
Project Officer: Dr. Ruth M. Heron

Intermodal Terminal Operations Simulation

Description

Although intermodal transportation of goods has become very attractive in recent years, the operation of container terminals in ports, rail yards, and trucking depots poses complex queueing problems. Simulation models can provide a means of overcoming this complexity by evaluating alternative equipment, layout, and operating procedures. Recognizing the potential benefits for the Canadian transportation industry, TDC has supported the development of an intermodal terminal operations simulation.

Interest in this development grew out of similar work by CN Rail in simulating its piggyback terminal operations.

It is hoped that improvements in the efficiency of container handling operations can be realized by applying lessons learned in the piggyback simulation model.

For this project, the contractor collected data on intermodal terminal operations, and from these developed and verified a computer simulation model. The model consists of two parts: a simulation of the terminal operations and a graphical post-processor. The simulation can evaluate various terminal layouts, equipment trade-offs, and yard operating policies.

The generated information is then converted into graphics and replayed on a display screen, animating major terminal operations. A key feature of the simulation is its machine dispatching logic, whereby a machine 'intelligently' chooses its next assignment. Although the model cannot trace a container's whereabouts after it leaves the terminal, nor determine switching required to separate intermodal flatcars from a train; it does provide a flexible and powerful analytic tool for the intermodal terminal designer.

Progress to July 1984

Technical work has been completed; reports are in preparation.

Contractor

Canadian National Railway, Montreal, Quebec

Reports

TP 5758E, Container terminal simulation model, user's manual, Canadian National Railway.
Draft (TP 5759E), Container terminal simulation model, summary report, Canadian National Railway.

Schedule: March 1982 — November 1984

Funding: TDC-ARFP —	$124,400
Transport Canada Energy Program —	$ 43,000
CN Rail — (in kind)	$284,500
Total —	$451,900

Project Numbers: 4604, 4905
File Number: D-1450-129
Project Officer: Wayne G. Rowan

Convoy Canada Demonstration

Description

Convoy Canada is an intermodal transport concept designed to provide rail freight service to centres whose demands are too low to interest existing suppliers of intermodal transport.

Convoy Canada would operate unit trains according to a published schedule on a pre-determined route, with short stops at selected terminals for quick loading and unloading.

Implementing the Convoy Canada concept will contribute towards improving the efficiency, productivity, and capacity of rail freight transportation in Canada. It will also improve the economic and industrial development of the centres served and offer opportunities for further research on new equipment design.

The purpose of this project is to design and prepare a demonstration of the Convoy Canada service. This includes:

- selection of routes and terminals,
- definition of operating characteristics,
- preliminary equipment engineering investigation, and
- promotion of the concept by demonstration to industry and government.

Progress to July 1984

Preliminary work has been completed on many aspects of the project and presented to advisory committees. Plans for the second half of the project will be made in January 1985.

Contractor

B. Helm Associates Ltd., Toronto, Ontario

Report

None to date

Loading piggyback cars

Schedule: May 1983 — August 1985
Funding: TDC-ARFP — $285,000

Project Number: 4942
File Number: D-1465-289-2
Project Officer: Trevor Smith

SURFACE TECHNOLOGY

Surface Technology

In Canada, most goods and people travel by highway. The highway system is the backbone of the country, and maintenance of the entire system has created demanding technical problems. Improved productivity for commercial users of the highway system will benefit both the national economy and individual Canadians. Yet, Canada's highway system is predominantly a provincial responsibility with many private sector firms and the general public as users. Accordingly, the bulk of TDC's highway research program is jointly undertaken with the province and industry.

Although urban transportation is a municipal and provincial concern, TDC is supporting projects in this field which contribute to federal government objectives, such as accessibility, energy efficiency, safety, and others of national interest and benefit.

In the area of accessibility, TDC is fostering the development of technology in equipment, systems, and procedures that make it possible for the elderly and disabled to use Canada's transportation services. The Canadian Human Rights Act prohibits discrimination against disabled persons in the provision of goods and services, including transportation.

Increased transportation efficiency can also be realized through technologies involving interfaces between modes or common factors applicable to several transportation system components. R&D in multimodal transportation as well as in the specialty areas of off-road transportation and tracked levitated vehicle technology, supports industrial initiatives and develops Canadian technical expertise.

HIGHWAY TRANSPORTATION

TDC's involvement in transportation research includes studies in three areas: highway infrastructure, highway bus technology and systems, and highway vehicles and systems.

The general aim of TDC's research in highway infrastructure is to minimize life-cycle costs of the highway system by introducing better methods for the design, construction, maintenance, and renovation of highway works. In particular, research is being conducted on pavement technology and soil and earthwork technology.

TDC's research in intercity bus technology is aimed at making this transportation mode more efficient and economical and, consequently, more attractive to the Canadian traveller. Advanced bus concepts, such as a double-deck design, as well as conventional highway buses, are being investigated.

TDC is committed to improving the safety and productivity of highway freight vehicles and systems. One project that will help realize this goal involves arriving at uniform regulations governing weights and dimensions for interprovincial trucking. Other projects underway address new technology for highway vehicle components.

URBAN TRANSPORTATION

One of the objectives of TDC's urban transportation research is to support industrial development of innovative transit technologies that are safer, more efficient, and energy-conscious.

In the area of energy conservation, TDC is studying energy management techniques for urban systems and co-operative ownership and usage of personal vehicles. To reduce Canada's dependence on petroleum-based fuels, TDC is also funding research on electric vehicle technology.

OFF-ROAD VEHICLES

TDC's aim in off-road transportation is to develop alternative means of transporting people and goods in the rugged terrains typical of Canada's remote and northern areas. Other research in this area concerns the development of an off-road rescue vehicle for airports with inaccessible surfaces around runways.

TRACKED LEVITATED VEHICLES

Tracked, magnetically levitated vehicle technology is an advanced concept in high speed intercity passenger transportation that uses non-contact vehicle suspension guidance and propulsion technology. TDC is sponsoring research into this futuristic transportation system to keep the Canadian transportation system modern and efficient.

TRANSPORTATION FOR ELDERLY & HANDICAPPED

TDC's transportation R&D program for the elderly and the handicapped is aimed at developing equipment, systems, and procedures that facilitate travel for Canadians with special needs.

Current research is addressing accessible vehicles, services, and facilities; technical aids for disabled drivers and travellers; and safety issues relating to wheelchair use and to pedestrian crosswalk systems.

MULTIMODAL TRANSPORTATION

Research projects in this area address technological and system developments that have application to more than one mode. Multimodal issues under study are transportation management, risk assessment, and systems safety methodologies.

Flyash cement and lignin cellulose cement stabilized soil samples

Testing for soil stabilization

HIGHWAY
TRANSPORTATION

Soil Stabilizer Evaluation

Description

Local soil (clay, silt, sand, or a mixture of these) is generally used for the construction of embankments or subgrades for streets, highways, railways, airport runways, and other constructions. Certain fine-grained local soils call for special design considerations because they swell or shrink when exposed to wet, dry, and frost conditions.

These soils are stabilized by using manufactured Portland cement or lime, but very little research has been done on the use of waste material or by-products for stabilizing soil used for construction of embankments or subgrades.

In keeping with Transport Canada's objectives to provide a more efficient transportation system, TDC has supported a comprehensive laboratory project that evaluated the economic benefits of using flyash and lignin cellulose as soil stabilizers, as well as the effect of using these procedures for the construction of highway, railway, and airport embankments. Samples of problem fine-grained soils were obtained from known sites in southern Alberta and tested for their natural characteristics, before being treated with flyash cement or lignin cellulose cement. The study concluded that lignin cellulose cement is a suitable stabilizer of silty and sandy soils, and may be cost-effective under certain conditions.

Liaison was maintained with provincial highway departments throughout the research project.

Progress to July 1984

This project has been completed.

Contractor

EBA Engineering Consultants Ltd., Calgary, Alberta

Reports

TP5287E, Laboratory evaluation of flyash cement and lignin cellulose cement as soil stabilizers, final report, 2 volumes, EBA Engineering Consultants Ltd., 1984.
TP5288E, Laboratory evaluation of flyash cement and lignin cellulose cement as soil stabilizers, summary report, EBA Engineering Consultants Ltd., 1984.

Schedule: March 1983 — March 1984
Funding: TDC — $40,000
DSS — $35,000
Total — $75,000

Project Numbers: 4925, 4926
File Number: D-1465-413
Project Officer: Wayne G. Rowan

Embankment Reinforcement Design

Description

The analysis of reinforcement for soft clay embankments is an integral and continuing part of TDC's highway and railway safety and efficiency objectives.

Soil stabilization is a constant factor in the evaluation of embankment soil. Clays, silts, sands, or a mixture of these soils, historically have been stabilized by using Portland cement or lime. The on-site strength and compression characteristics of most clays have generally been increased by stage loading techniques.

Very little research has been done on the concept of using reinforcing inclusions, especially polypropylene geo-grids, in embankments. In addition, there is no universally accepted method known for analysis of soft clay stability in embankments.

St. Alban, Quebec, has been chosen for research into reinforcing inclusions, because the soil characteristics are well known from previous studies. Reinforced and unreinforced embankments will be analyzed using traditional limit equilibrium methods, followed by comparative mathematical modelling of the embankment and its foundation.

The test embankments will comprise three 20 x 40 metre instrumented sections: one reinforced with horizontal strips of geo-grids; a second, unreinforced control section; and a third reinforced with Tensar "sand cells." One side of the fill will be maintained by a berm to inhibit failure; failure will be induced on the opposite side.

The field data will be analyzed and compared with the predictions by the analytical methods.

Progress to July 1984

The geotechnical investigation and the stability analysis have been carried out. All three test embankments have been designed; two of them have been instrumented. The finite element modelling is 50% complete.

Contractor

Golder Associates (Eastern Canada) Ltd., Mississauga, Ontario

Report

None to date

Schedule: February 1984 — March 1985

Funding: TDC —	$ 61,800
DSS —	$150,000
NRC —	$ 25,000
EMR —	$ 15,000
Total —	$251,800

Project Numbers: 6159, 6160, 6162
File Number: D-1465-437
Project Officer: Wayne G. Rowan

High-Capacity Coach Design

Description

If ride quality and fuel efficiency were improved, coaches would offer the Canadian public an attractive substitute for air, train, and automotive travel on many short-haul routes.

In line with this goal, this project is developing several conceptual design options for a highly advanced and efficient double-deck coach to be manufactured in Canada.

To do this, the contractor will be completing the following tasks:

- assessing current and future operational requirements;
- evaluating subsystems and alternative fuel considerations;
- preparing conceptual designs, preliminary industrial designs, and configuration studies;
- constructing and testing scale models of optional coach designs;
- estimating fuel consumption at various speeds and comparing performance with existing coaches;
- assessing technical risks of the options;
- estimating both production and life cycle costs; and
- assessing market potential for a double-deck intercity coach.

Although this project does not include prototype manufacturing drawings, the contractor will complete engineering drawings of the alternative options which, along with the other completed tasks, will provide a basis for proceeding to the prototype fabrication stage.

Progress to July 1984

Operational requirements have been assessed and subsystem evaluation has been completed. Conceptual design options are being prepared.

Contractor

Urban Transportation Development Corporation R&D Ltd., Kingston, Ontario

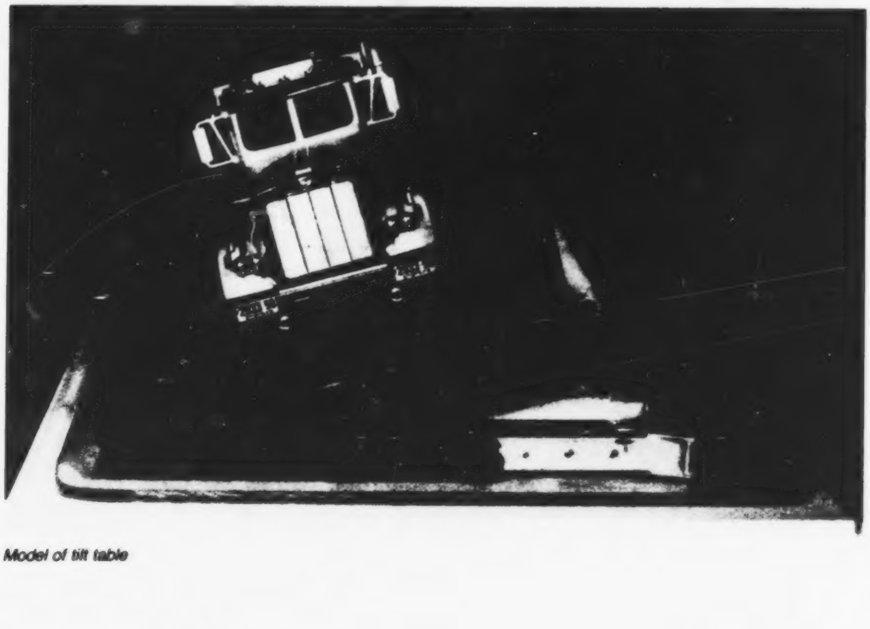
Report

None to date

Schedule: December 1983 — February 1985

Funding: TDC —	$ 64,300
Transport Canada Energy Program —	$200,000
Total —	$264,300

Project Numbers: 6087-8
File Number: D-1465-280-5
Project Officers: Trevor Smith, Catherine Hirou



Model of tilt table

Weights and Dimensions Study

Description

Efficient truck traffic throughout Canada is significantly hampered by the wide variations in trucking regulations between provinces. The lack of uniform regulations is particularly serious in authorized vehicle weights and dimensions. Western Canada, for example, permits greater overall length limits than Eastern Canada. On the other hand, allowable weight limits are higher in the east than in the west. As a result, interprovincial carriers must operate at the lowest common denominator in terms of the weights and configurations permitted in all provinces.

The overall objective of this extensive research program is to arrive at the criteria necessary to develop uniform weight and dimension regulations throughout Canada. To accomplish this goal, researchers are involved in two related areas of investigation:

- stability and control of the major vehicle types now operating in Canada; and
- pavement response to heavy vehicles.

On the stability and control side, computer simulations will be used to evaluate the effect of such factors as gross and axle weight, suspension type, and tire type on a number of truck configurations. The validity of the simulated vehicle responses will be verified by extensive field tests. One of the tests to be performed as part of this project requires that a tilt table to measure static rollover be designed and built.

The second focus of this study deals with the impact of various weight and dimension configurations on highway pavement. The program will evaluate the comparative impact of different axle and wheel load combinations on fifteen instrumented test pavements across Canada. The actual forces imposed on the road by various suspension systems will also be measured in a dynamics laboratory.

The results of this study will assist both vehicle designers and highway regulators in the design and approval of new vehicles.

Progress to July 1984

This study is proceeding on schedule. The design and construction of the tilt table is advancing, as well as the modelling and simulation work. Pavement test sites have been selected and instrumentation has begun.

Contractor

Roads & Transportation Association of Canada, Ottawa, Ontario

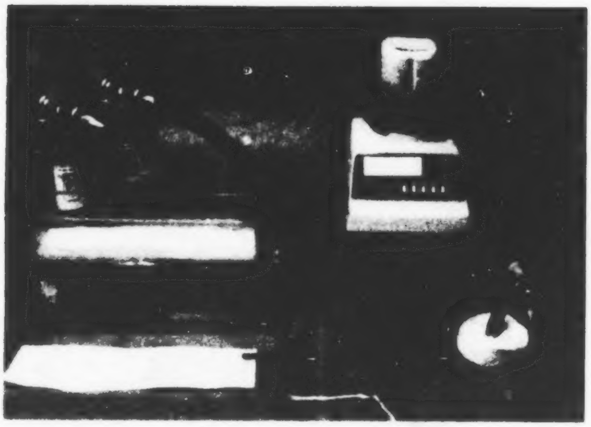
Report

None to date

Schedule: April 1984 — October 1987
Funding: TDC — $658,000

Project Number: 6175
File Number: D-1465-421
Project Officer: Lewis SaboungHi

Assembled Ni/Zn cell



Zinc electrode fabrication
1. dry mix in beaker
2. mix slurried in blender
3. slurry filtered
4. grid placed on filtered mix

Ni/Zn Battery Research for Cold Weather Engine Starting

Description

The nickel zinc (Ni/Zn) battery is considered superior to the standard lead-acid battery when applied to starting diesel and large gasoline engines because it has a higher watt-hour/kilogram energy density. Furthermore, its charging capacity does not deteriorate as abruptly as the lead-acid battery. This is particularly true in cold weather conditions.

The major disadvantage of the Ni/Zn battery is the unacceptably low number of charge/discharge cycles it can withstand. However, a recent feasibility study supported by TDC found that certain alloys might inhibit dendrite formation, thus increasing the number of charge/discharge cycles.

As a result of these findings, TDC is supporting this project to evaluate the performance of various alloys under high current discharge conditions. This work will determine the suitability of these alloys for low temperature battery applications.

After completing an evaluation of the properties of various alloys, the contractor plans to design, construct, and test experimental cells fabricated from these alloys. Cells with conventional current collectors also will be constructed and tested for comparison purposes.

The first series of tests will measure and compare cell performance in the 0°C to -40°C temperature range. Further research will examine the effects of base metal composition, coating and paste composition, and grid design on high rate discharge characteristics.

Finally, the contractor will construct and test an experimental cell that will have the optimum components based on the previous evaluations.

Progress to July 1984

During the first year of this two-year research and development project, the contractor evaluated the effects of additives to the zinc-active material, using various electrode fabrication methods. One additive was found to greatly increase the number of cycles and permit much higher utilization of the active material.

Contractor

Cominco Ltd., Mississauga, Ontario

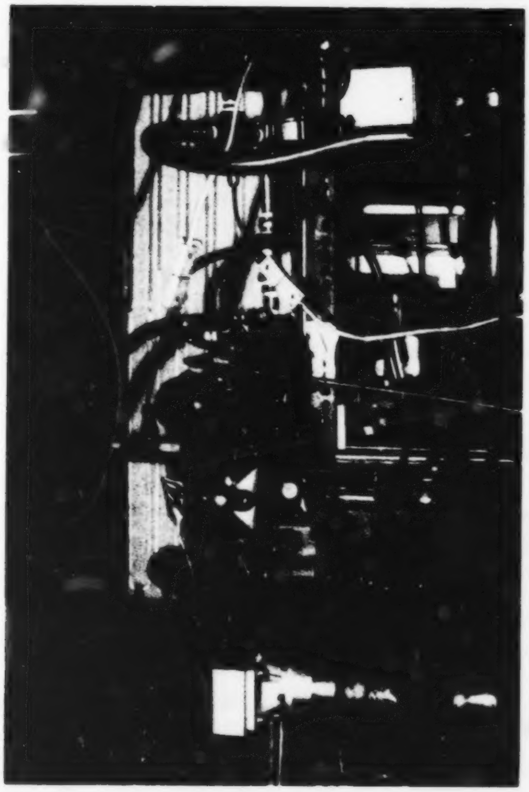
Report

None to date

Schedule: July 1983 — July 1985

Funding: TDC —	$ 40,000
DND —	$ 40,000
Cominco Ltd. —	$ 80,000
Total —	$160,000

Project Number: 6029
File Number: D-1465-417
Project Officer: John H. Morgan



Diesel fuel injection pump

Front view of test engine

Ignition of Propane in Diesel Engines

Description

The substitution of propane for diesel oil is a practicable way of reducing Canada's dependence on oil-based fuels. Virtually all heavy duty and an increasing number of medium and light duty vehicles are operated with diesel fuel. Efficient and reliable propane conversion equipment has not yet been developed.

Because propane has a very low cetane number, either a glow plug or timed-spark ignition is needed for proper combustion. Fuel injection is delayed in order to retain the high compression ratio (and thus efficiency) of a diesel engine, without pre-ignition.

The objective of this research project is to determine the most suitable type of ignition source for propane. In order to achieve this, the combustion characteristics of propane will be studied in detail.

Specifically, researchers will complete the following tasks:

- conduct a series of baseline tests on an engine with diesel oil as fuel. Power output, fuel consumption, and emissions will be measured at four speed settings;
- modify the existing injection pump/fuel system to be compatible with propane. In addition, adapters will be designed and fabricated to enable the installation of various glow plugs; and
- conduct comparable tests with propane fuel. Power output, fuel consumption, and emissions will be measured at the same four speed settings as used when testing diesel oil as fuel.

Progress to July 1984

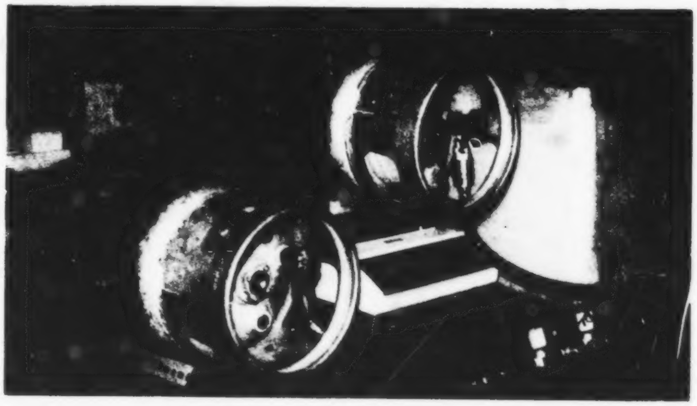
Baseline tests of the diesel fuel-operated engine are nearing completion.

Contractor

University of Toronto, Department of Mechanical Engineering, Toronto, Ontario

Report

None to date



Liquid propane gas tanks and consumption measurement equipment

---

Schedule: August 1983 — May 1985
Funding: Transport Canada Energy Program — $116,000

Project Number: 6060
File Number: D-1465-372-3
Project Officer: John H. Morgan

Urban Transportation Energy Management

Description

As a major portion of energy consumption is urban-based, a more efficient urban transportation system would contribute significantly to Canada's energy conservation measures.

Although various energy conservation programs and studies have been conducted, no comprehensive study on a national scale provides an indication of the total potential energy savings in Canada through urban transportation energy management programs.

This research project developed a national framework for urban transportation energy management, taking into account urban transportation system characteristics for passengers and goods. The major elements of the study included:

- identification, review and quantification of urban transportation system characteristics in five city-size groupings. This information provided a means by which to estimate base energy consumption as well as the potential savings that could arise from implementing specific measures;
- review of various transportation management measures and the associated energy impact;
- evaluation of the ten "best" measures for each city-size grouping. This ranking provides an initial indication of preferred measures that should be considered by transportation planners and engineers in developing comprehensive energy management programs; and
- recommendation of a research and development program taking into account the potential energy savings of the various measures.

Progress to July 1984

This project has been completed.

Contractor

IBI Group, Toronto, Ontario

Reports

TP 4793E, A national framework for urban transportation energy management, final report, IBI Group, 1983.

TP 4915E, A national framework for urban transportation energy management, summary report, IBI Group, 1983.

Schedule: September 1982 — October 1983

Funding: Transport Canada Energy

Program —	$40,000
EMR —	$30,000
Total —	$70,000

Project Numbers: 4753, 4758

File Number: D-1450-131

Project Officer: Ling Suen

SailRail Application to Transit

Description

This project addresses Canada's aim to improve the efficiency of its passenger transportation systems through an investigation of air bearing SailRail technology. The technique, developed by SailRail Enterprises for the materials handling industry, uses a thin layer of air to reduce friction between a loaded pallet and the track over which it travels. It is currently being used to transport freight over short distances at terminals and warehouses.

In an earlier project, researchers at the University of Toronto studied the feasibility of applying SailRail technology to the intermodal transfer of freight and passengers by powering it with a linear induction motor (LIM). The study noted that because vehicle suspension would be eliminated, the LIM/SailRail combination would enable the construction of a light, simple vehicle suitable for either freight or passenger transport. Furthermore, it would be highly reliable and require low maintenance. Although these and other advantages would make such a system very economical, researchers identified a number of critical technical problems that must be resolved before the commercialization of the LIM-powered, air bearing SailRail technology can take place.

In this project the contractor, Urban Transportation Development Corporation (UTDC), will design and construct a small demonstration system that will operate for three months. Researchers will evaluate:

- the system's ability to operate in an unprotected environment;
- its ability to negotiate curved rails;
- its ability to queue and restart the vehicles; and
- means of detecting pedestrians or obstacles.

Progress to July 1984

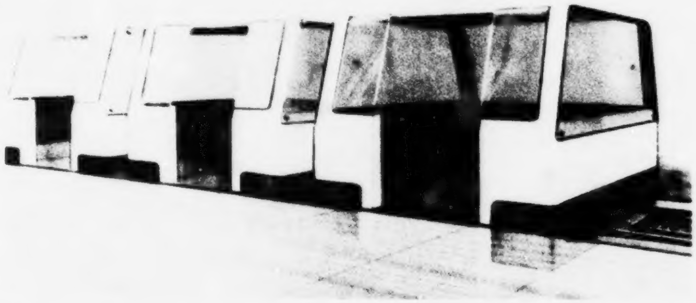
The three-month demonstration at the UTDC test facility is almost complete.

Contractor

Urban Transportation Development Corporation, Kingston, Ontario

Report

None to date



Artist's rendering of a SailRail passenger transport system

Schedule: March 1983 — October 1984
Funding: Transport Canada Energy
Program — $287,600

Project Number: 4976
File Number: D-1465-310-4
Project Officer: C. Alfred Versailles

Shared Vehicle Fleets: Institutional Issues

Description

The concept of a shared vehicle fleet (SVF), in which jointly owned, operated or accessed vehicles supplement or replace personally owned vehicles, has significant potential for reducing fuel consumption in the private passenger transportation sector.

In an earlier TDC-sponsored study, researchers reviewed recent trends in household expenditures on transportation, travel behaviour, and alternative work schedules and found theoretical opportunities for SVF schemes in Canada. A six-step feasibility study, culminating in a demonstration program, was developed to determine the true propensity of Canadian households to participate in SVF schemes.

The first step of this study involved monitoring current and emerging SVF schemes and visiting potential demonstration sites.

In the current project, which constitutes the second step of the study, the contractor is reviewing the institutional issues involved in SVF schemes. These include registration, insurance, administration, licensing of rental agencies or brokers, regulations at all government levels, legal agreements, and competition with other services.

Progress to July 1984

Consultations with insurance companies, taxi and transit operators, and government agencies are in progress.

Contractor

Jouko A. Parviainen & Associates, Oakville, Ontario

Report (from earlier research)

TP 4569E, Shared vehicle fleet concepts, state-of-the-art review and R&D program definition, Jouko A. Parviainen & Associates, 1983.

Schedule: May 1984 — June 1985
Funding: Transport Canada Energy Program — $30,000

Project Number: 6184
File Number: D-1465-391
Project Officer: Ling Suen

Hybrid Vehicle Research

Description

Electric and hybrid vehicles are recognized throughout the industrial world for their low oil consumption. Current battery technology, however, allows only a range of 40-64 km between recharges, seriously restricting the market for such vehicles.

TDC research had suggested that a hybrid vehicle would be acceptable to a significant proportion of urban vehicle operators. The vehicle would be equipped with a small internal combustion engine for better acceleration and longer range, but otherwise would use electrical energy for its operation. The aim of this project was the design of an advanced propulsion system that would increase the performance and range of such a hybrid vehicle.

The project was divided into two phases. Phase I included:

- development of performance specifications,
- investigation and selection of drive train configuration and components,
- selection of chassis and body materials,
- design of vehicle layout,
- calculation and computer modelling of performance, and
- verification of safety standard compliance.

Phase II called for assembling and testing the propulsion system.

Progress to July 1984

This project was terminated after Phase I. Research showed that there is no market for this type of device under current economic conditions.

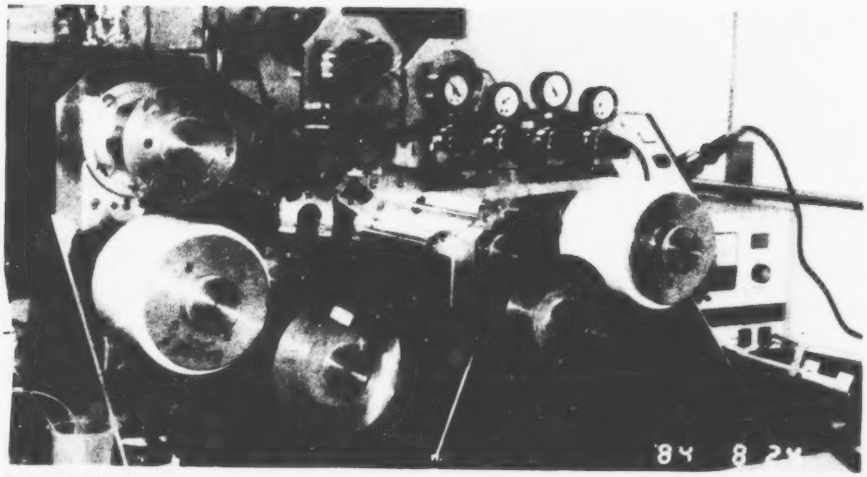
Contractor

Marathon Electric Vehicle Inc., Montreal, Quebec

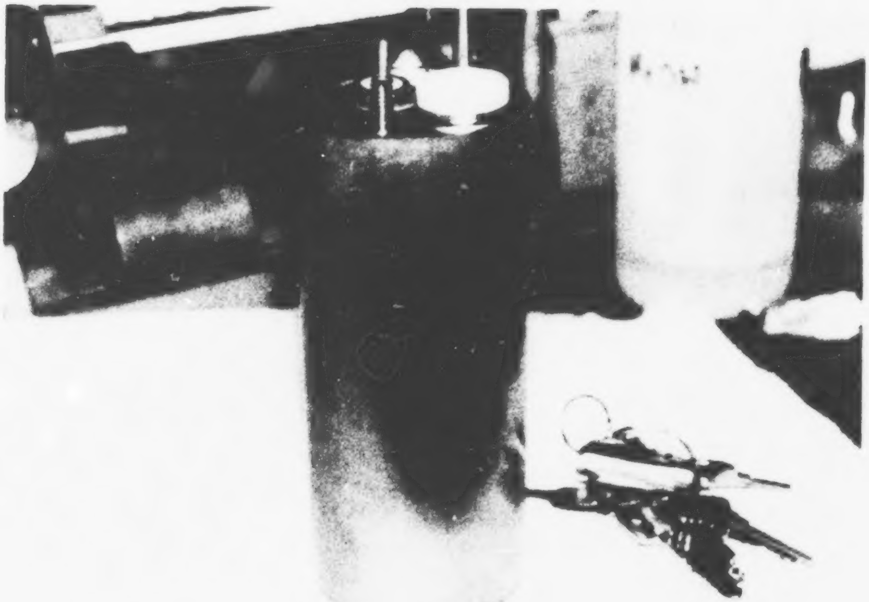
Report

Draft (TP 5301E), A design study of propulsion systems for a hybrid vehicle, Marathon Electric Vehicle Inc.

Schedule: February 1983 — January 1984		**Project Numbers:** 4571, 4572
Funding: TDC —	$ 52,000	**File Number:** D-1465-145-4
DSS —	$190,000	**Project Officer:** John H. Morgan
Total —	$242,000	



Fabrication of cell components



Assembled 50 ampere-hour, 12 volt Moli battery

Large Moli Battery Development

Description

Advancements in electric vehicle technology could reduce Canada's current dependence on petroleum-based fuels. There is no doubt that the battery is a vital and critical element of electrical vehicle development.

Recent tests conducted by Moli Energy Ltd. suggest that the "C" size cell of its Li MoS_2 battery can be scaled up to EV size, and promises to triple the range of an EV. This would allow it to undertake a much larger proportion of motor vehicle functions.

This project's aim is to develop a 50 ampere-hour, 12 volt Moli battery that would have much greater energy storage capabilities and power delivery than a lead-acid battery.

The first phase of the project consisted of the engineering analysis and detailed design of the 50 ampere-hour cell, followed by fabrication. The battery will undergo a comprehensive testing program.

Performance tests will measure the battery's energy storage capacity, maximum peak and sustained power, and overall efficiency. Safety testing will include short-circuit, mechanical shock and vibration, and thermal shock tests. The final testing stage will measure the battery's in-service capabilities.

Progress to July 1984

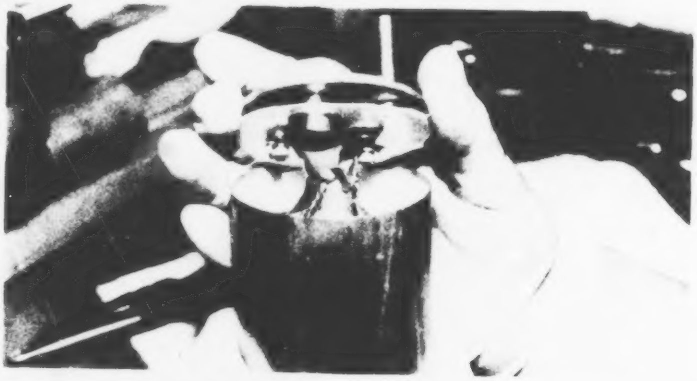
The cells have been manufactured and meet requirements. They are being assembled into 12 volt batteries for further testing.

Contractor

Moli Energy Ltd., Burnaby, British Columbia

Report

None to date



Schedule: April 1984 — March 1985

Funding:	
TDC —	$ 50,000
Transport Canada Energy Program —	$ 50,000
DSS —	$200,000
DND —	$ 20,000
Canadian Electrical Association —	$100,000
Total —	$420,000

Project Numbers: 6258, 6259
File Number: D-1465-416-3
Project Officer: John H. Morgan

Advanced Battery Charger for Electric Vehicles

Description

Most battery chargers are too heavy or bulky for practical use in vehicles. The existing smaller chargers do not permit charging to maximum capacity, which can result in the early failure of expensive cells.

Chargers use transformer-rectifiers, which impose heavy inductive loads on power utilities. A higher power factor will be necessary as the number of electric vehicles increases: numbers that will lead to a greater demand for charging at the same time of day. The objective of this project is to develop an efficient, lightweight, microprocessor-controlled battery charger for installation in electric vehicles.

Researchers have developed a specification for an advanced battery charger. New circuit designs have been evaluated; an engineering prototype has been designed and tested; and, three units have been manufactured for in-service testing.

Progress to July 1984

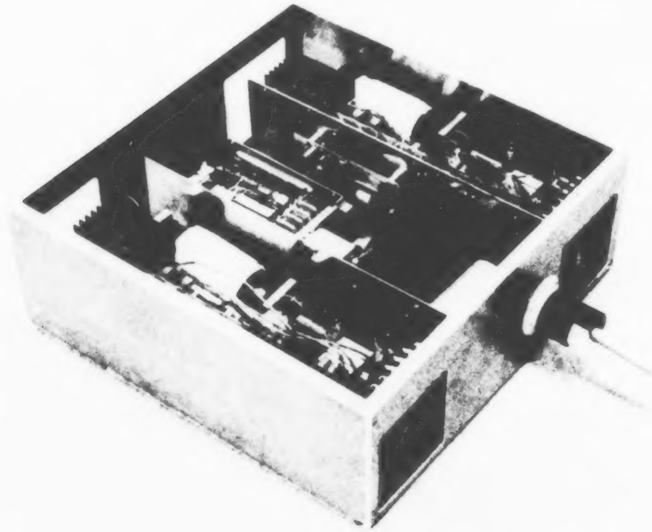
Tests of a breadboard circuit have produced encouraging results, leading to packaging of the charger circuit into a unit suitable for field testing.

Contractor

AC Statpower Inc., Vancouver, British Columbia

Report

None to date



Prototype battery charger

Schedule: July 1981 — September 1984

Funding: TDC —	$15,000
DSS —	$34,000
Total —	$49,000

Project Number: 4442
File Number: D-1465-351
Project Officer: John H. Morgan

Lightweight Bogie for Intermediate Capacity Transit Systems

Description

The most important design element for an intermediate-capacity rail vehicle is the bogie, which has had a major impact on size, appearance, ride quality, and cost.

This project involved the design, construction, and testing of two prototype motorized bogies that are smaller, easier to fabricate, lighter in weight, and less expensive than the conventional bogie.

In designing these prototypes, careful attention was placed on how the bogie's main functions (to support, guide, link, and filter) have an effect on the safety, maintenance costs, and comfort of the car.

The prototype bogies were mono-motor, which allows them to be smaller and lighter. A dynamic and structural analysis was made on the prototypes in order to simulate and verify the car's performance under different operating conditions and to validate the design of the frame.

The prototype bogies were manufactured and then sent to Pueblo, Colorado, for dynamic track testing.

The report suggests that a mathematical model may need to be developed to simulate curve entries. It recommends that the concepts of radial and independent wheel bogies be considered. These types of bogies offer important advantages over the conventional bogie in terms of lateral stability, curve handling, and wear reduction at the wheel/rail interface.

Progress to July 1984

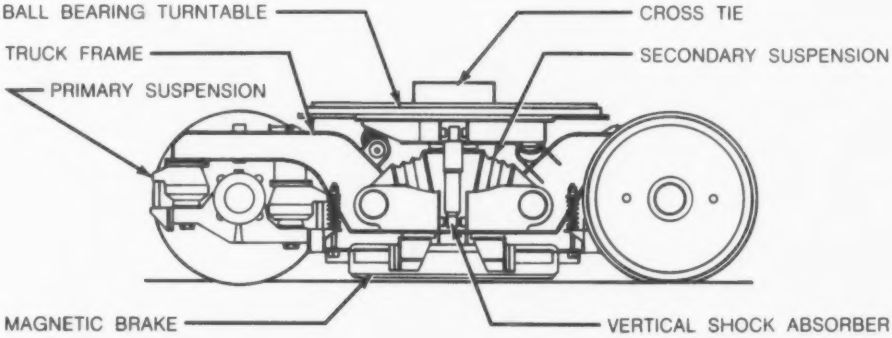
This project has been completed.

Contractor

Bombardier Inc., Montreal, Quebec

Report

Draft (TP 5590F), Bogie prototype, Bombardier Inc.



Sketch of lightweight motorized bogie

Schedule: March 1979 — March 1984

Funding: TDC —	$ 540,000
Transports Québec —	$1,027,000
Bombardier Inc. —	$ 200,000
Total —	$1,767,000

Project Number: 7644
File Number: D-1465-256
Project Officer: Maurice Audette

Study of Aerobac as an Airport Emergency Vehicle

Description

The Aerobac is an off-road amphibious vehicle that integrates an air cushion lift system with caterpillar traction. This project was initiated to analyze the effectiveness of the Aerobac AB-7 as a rescue vehicle at airports where surface conditions around the runways and taxiways make access by existing vehicles difficult or impossible.

The feasibility of this concept has been verified previously by TDC. Favourable characteristics were:

- low surface contact pressure,
- mobility of tracks on and off cushion, and
- no need for special driving skills.

Researchers studied the terrain at two airports: Vancouver International, where flood tides cover parts of the land adjacent to runways; and the airport at Baie Comeau, Quebec, where the surrounding land consists of organic soils with a bearing strength that varies widely with the seasons. Researchers calculated mean response times for various sections of each airport, using the performance characteristics of the Aerobac AB-7. They also developed cost estimates for a prototype vehicle, and explored the possibility of using the AB-7 to carry rescue equipment.

Simulations showed that the Aerobac AB-7 remains mobile and responds in reasonable time in snow and mud flat, as compared with the Foremost, an existing wheeled rescue vehicle, which is immobile under these conditions. The AB-7 is also superior to the Foremost in marginal terrains (muskeg). Its air cushion lift broadens the range of terrain over which it can operate.

Progress to July 1984

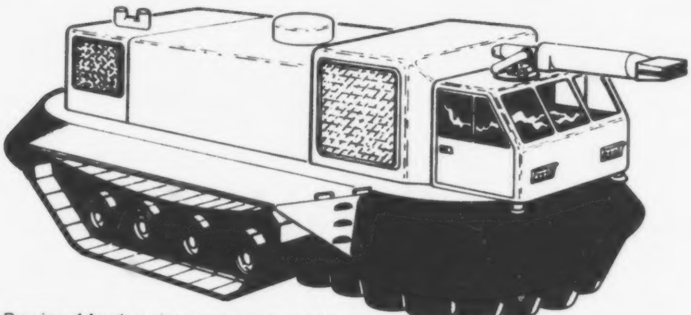
This project has been completed.

Contractor

Intercan Logistical Services Ltd., Montreal, Quebec

Report

TP 5116E, Study of Aerobac AB-7 vehicle for airport rescue in difficult terrain, Intercan Logistical Services Ltd., 1983.



Drawing of Aerobac airport emergency vehicle

Schedule: March 1983 — December 1983
Funding: TDC — $90,000

Project Number: 4854
File Number: D-1465-258-4
Project Officer: Jacques E. Laframboise

Arctic Snowmobile Design Study

Description

The snowmobile has become an integral part of the transportation system in Canada's arctic regions. It provides personal transportation in a style that is acceptable to the local population, and has largely replaced the traditional dog-sled. The snowmobile is essential for hunting and trapping, on which much of the northern economy is based, and is the principal means of short-distance travel.

The recreational snowmobile used by the southern population, however, is not sufficiently rugged or reliable for the arctic environment. Previous research supported by TDC identified some design changes by which the recreational snowmobile could be adapted to utility service in the north.

In this project a snowmobile was designed to meet arctic requirements. It incorporates a larger cargo area than the recreational vehicle, together with a towing capacity for a one-ton komatik, and short-term flotation capability for ice breakthrough.

Further investigation showed that an arctic utility snowmobile could be marketed as a kit, similar to those available for cars and aircraft. The kit could be assembled by local northern communities, and augmented by options as required for specific needs. Furthermore, the cost of a mid-sized vehicle in kit form would be competitive with that of the recreational snowmobiles sold in the north.

Demand for snowmobile kits would not exclude the availability of complete machines where required.

Progress to July 1984

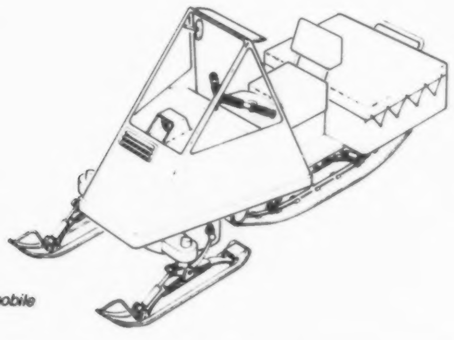
This project has been completed.

Contractor

Nunasi Corporation, Ottawa, Ontario

Report

TP 5498E, Arctic snowmobile design study, Nunasi Corporation, 1984.
TP 5728E, Arctic snowmobile design study, summary report, Nunasi Corporation, 1984.



Sketch of the arctic snowmobile

Schedule: March 1983 — July 1984
Funding: TDC — $40,000
DSS — $50,000
Total — $90,000

Project Number: 4894
File Number: D-1465-320-2
Project Officer: Jacques E. Laframboise

Evaluation of a Hybrid Cellular Air Cushion Skirt

Description

The need for improved off-road transportation in remote and northern areas of Canada has prompted investigation of multicellular skirt systems. These systems feature high roll stiffness, a desirable characteristic for overland air cushion vehicles, which tend to be long and narrow.

The original Bertin multicell design comprised conical skirted cells to which a peripheral skirt was added to increase active cushion area and reduce the air escape perimeter. In high roll conditions, however, this system produces buckling, which prevents rapid recovery.

In the Flexicell multicellular skirt, independent cells are mounted on removable frames. Since the cells are in close contact with one another, there is no need for a peripheral skirt.

The hybrid version studied in this project has outer cell walls with a greater slope than the multicell system. When the pressure increases to maximum in the cell, collapse of the wall causes the cushion's centre of pressure to move towards the low side. (This is equivalent to the action of a segmented skirt, hence the word "hybrid.") The hybrid cellular system, therefore, has greater roll resistance than the classic multicell system.

Researchers constructed a 1:5 and a 1:3 scale model of a proposed five-tonne vehicle. The models were tested statically and dynamically over solid surface and water for roll, pitch, and heave stiffness at three fan power levels.

Progress to July 1984

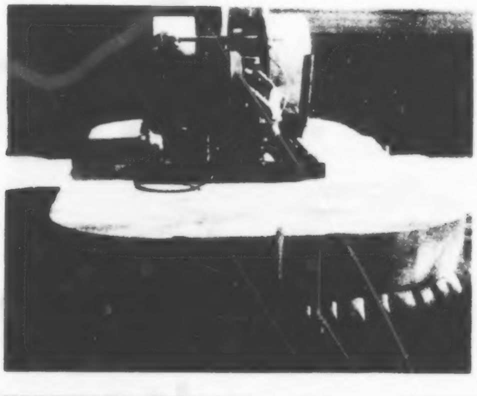
Technical work is nearing completion.

Contractor

Jones, Kirwan and Associates, Hamilton, Ontario

Report

None to date



Model of air cushion vehicle equipped with hybrid cellular skirt

---

Schedule: November 1982 — December 1984

Funding: TDC — $32,000

DSS — $20,000

Total — $52,000

Project Number: 4790

File Number: D-1460-185

Project Officer: Jacques E. Laframboise

Comparative Study of TransRapid EMS and Electrified LRC

Description

Today's transportation planners have two basic technologies available to them: an advanced high-speed rail system based on conventional principles, and a non-contact system using magnetic levitation.

Recognizing this choice and looking to the future when high-speed guided ground transport systems may be built in Canada, TDC sponsored a comparative assessment of the two systems. The study identified, evaluated, and analyzed the major differences between the two technologies, accounting for their levels of service, capital costs, annual costs, and impacts. Researchers also compiled a comprehensive technical and financial data base to help transportation planners and decision makers compare the two systems.

The contractor took into consideration the contextual characteristics of a specific application: a high-speed service between Ottawa and Montreal with at least one intermediate station at Mirabel International Airport.

The resulting research defined conceptually a complete system for each technology that covered all components for a Montreal-Mirabel-Ottawa corridor. For both systems, a financial analysis is available as well as findings in major differences of impact such as: technical spin-offs, employment creation, and environmental factors.

Progress to July 1984

This project has been completed.

Contractor

Canatrans Inc., Montreal, Quebec

Subcontractors

TransRapid, Munich, Federal Republic of Germany
Queen's University, Canadian Institute of Guided Ground Transport, Kingston, Ontario

Report

Draft (TP 5457E), Comparative technology assessment: Montreal-Mirabel-Ottawa, Canatrans Inc.

Schedule: September 1982 — September 1983
Funding: TDC — $250,000

Project Number: 4609
File Number: D-1465-356-2
Project Officer: Maurice Audette

Homopolar Linear Synchronous Motor Investigation

Description

The interest in high-speed intercity rail and automated transit systems is growing rapidly, and with it, the need for non-contact propulsion systems that can provide thrust independent of weather and wheel/rail adhesion.

One possible solution, the linear induction motor (LIM), has been under development for some time; but its efficiency, and the power factors achieved, have been disappointingly low.

Previous work sponsored by TDC has shown that the homopolar linear synchronous motor (HLSM) may be an acceptable alternative, because it is capable of high efficiency and power factors. These advantages could, however, be offset by increases in motor weight.

Researchers reviewed the current information on HLSMs; defined a HLSM design specification based on propulsion needs of an LIM-powered intermediate capacity transit system; and, developed techniques for testing performance.

A HLSM equivalent circuit model computed routine performance parameters affecting acceleration, cruising, and braking conditions. A preliminary HLSM design for an intermediate capacity transit system has also been reviewed.

Progress to July 1984

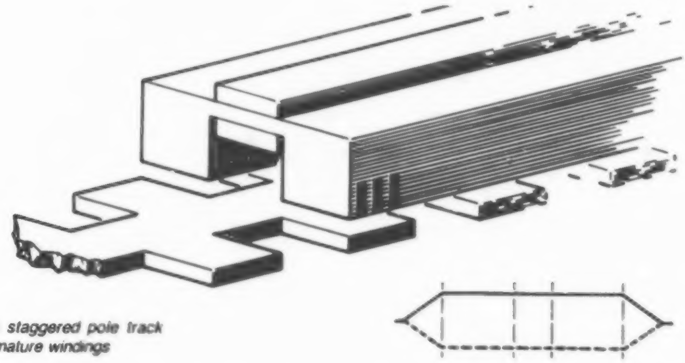
Technical work has been completed; reports are in preparation.

Contractor

Queen's University, Canadian Institute of Guided Ground Transport, Kingston, Ontario

Reports

Draft, Analysis and assessment of the homopolar linear synchronous motor, Queen's University, Canadian Institute of Guided Ground Transport.
Draft, Analysis and assessment of the homopolar linear synchronous motor, summary report, Queen's University, Canadian Institute of Guided Ground Transport.



HLSM configuration with staggered pole track and diamond-shaped armature windings

---

Schedule: November 1982 — June 1984
Funding: TDC — $106,500

Project Number: 4603
File Number: D-1465-288-2
Project Officer: Maurice Audette

Wheelchair Access to an Intercity Coach

Description

Elderly and handicapped travellers face a number of accessibility problems when they use transportation systems. Among them is the lack of means for wheelchair users to access intercity buses. To address this and other obstacles, the Canadian Transport Commission conducted an inquiry into Newfoundland's federally-operated Road Cruiser Service in the late '70s. As a result of the investigation, Transport Canada will implement a 3-year demonstration of an accessible MC-9 intercity coach as part of its commitment to improving transportation for these travellers.

An elevator-style wheelchair lift system, called the El-lift, was selected for the demonstration. Its design is being modified as the system was originally proposed for new articulated buses.

The development of the prototype El-lift system for installation in an existing MC-9 coach is being conducted in three phases.

In the first phase, installation requirements, assessment of technical risks, and cost estimates were determined. During the second phase, attention was placed on engineering development, industrial design, stress evaluation, and redesign of the MC-9 structure.

The third, and current, phase of this project involves completing the modified design of the El-lift, and fabricating and installing it in the MC-9 coach.

Before installation, the lift will be tested through its operational procedures to ensure that all safety features respond as expected and that multiple fail-safe modes interact as designed. Once the satisfactory operation of the components is established, the El-lift will be installed in the bus and retested as a complete system. The vehicle will be driven over several hundred miles of highway, paved, and secondary roads to test the integrity of the frame modifications. After road testing, the 3-year demonstration will begin in Newfoundland.

Progress to July 1984

All concerns about structural integrity were resolved in the second phase. Detailed manufacturing drawings, maintenance and operating manuals are being prepared. The vehicle will be delivered in December 1984.

Contractors

Lugano Enterprises, Winnipeg, Manitoba
Transitec Industries Ltd., Winnipeg, Manitoba
TES Ltd., Ottawa, Ontario

Report

None to date

Schedule: November 1983 — February 1985
Funding: TDC — $150,000
CSTA — $150,000
Total — $300,000

Project Numbers: 6113,6168, 6319
File Number: D-1465-433
Project Officers: Trevor Smith, Brian Marshall

Commuter Rail Access for Disabled Persons

Description

There are currently two transportation service concepts for disabled passengers. One is referred to as parallel service, where special vehicles are used to carry only disabled travellers. The other is an integrated approach where disabled persons have access to the same vehicles and facilities used by able-bodied travellers.

The aim of this study is to determine the feasibility of providing an integrated, door-to-door transportation service using an accessible car on a commuter train combined with an accessible feeder, such as a bus, taxi, or van. Included in this feasibility study will be a cost analysis of the integrated service over a 30-year period.

Phase I examines two commuter rail routes, as case studies, which could be modified to provide an integrated, door-to-door transportation service: Lakeshore West, Toronto, and Rigaud Line, Montreal. Headways, ridership, distance between stations, travel time, feeder systems, fares, and the role of staff will be investigated together with population base and demand by the disabled. Based on this research, the contractor will propose feasible options for the integrated service.

In phase II, researchers will analyze and compare the cost effectiveness of the integrated service options. Finally, the capital and operating costs of a parallel service along the same routes will be determined and compared to the proposed integrated service.

Progress to July 1984

The demographic analysis has been completed and a detailed work plan developed.

Contractor

James F. Hickling Management Consultants Ltd., Ottawa, Ontario

Report

None to date

Schedule: May 1984 — June 1985
Funding: CSTA — $99,600

Project Number: 6071
File Number: D-1450-103-56
Project Officer: Ling Suen

Computerized Scheduling and Routing of Special Public Transit Services

Description

More and more disabled Canadians are turning to special public transit services to travel in and around their town or city. This escalating demand calls for increased efficiency and availability of these transit services, often resulting in their expansion in size and scope. Manual scheduling and routing of larger transit systems is difficult, but no satisfactory computer model for this purpose exists at present. The objective of this research project is to develop an advanced computer model that can be used to automatically schedule and route transit services for disabled persons.

The computer model under development uses the data base available in the Area Master Files compiled by Statistics Canada, these being records of geographical data from which the distance between two given locations can be determined. Using the travel distances between pick-up points and other information such as origins and destination of passengers and time of pick-up and drop-off, the model provides automatic scheduling and routing of transit services. It also promises to be useful for analyzing the impact that different operational scenarios may have on the complexity and quality of routing for special transit services.

Researchers are testing the computer model, using data compiled on three cities of different size, preparing a user's manual, and documenting the test results.

Progress to July 1984

Technical work has been completed; reports are in preparation.

Contractor

Centre de recherche sur les transports, Université de Montréal, Montreal, Quebec

Reports

Draft (TP 5596E), Routing and scheduling for the transportation of disabled persons, the algorithm, Centre de recherche sur les transports, Université de Montréal.

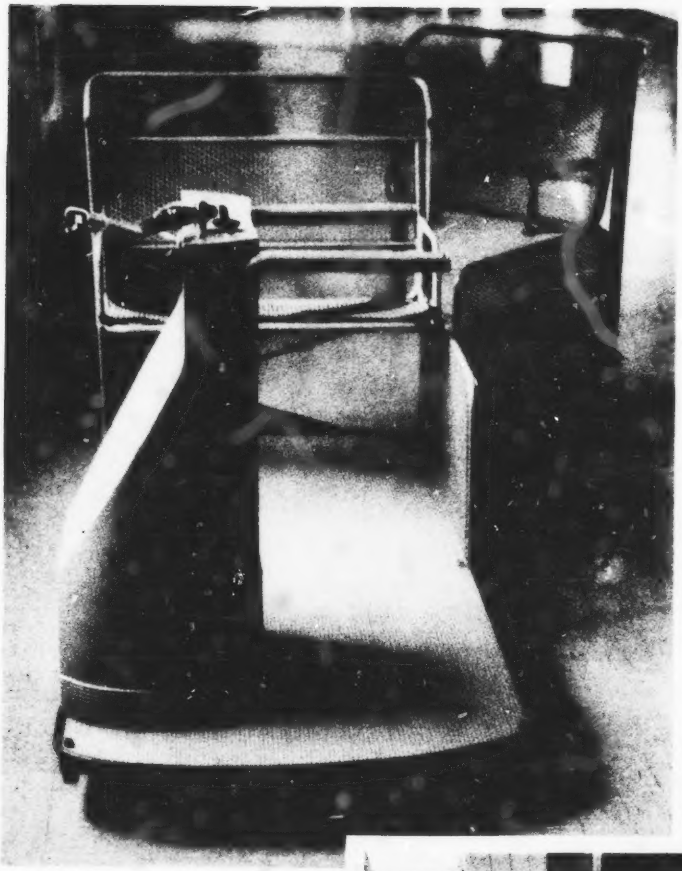
Draft (TP 5597E), Routing and scheduling for the transportation of disabled persons, the user's manual and computer programs, Centre de recherche sur les transports, Université de Montréal.

Draft (TP 5598E), Routing and scheduling for the transportation of disabled persons, the test problems and the evaluation of results, Centre de recherche sur les transports, Université de Montréal.

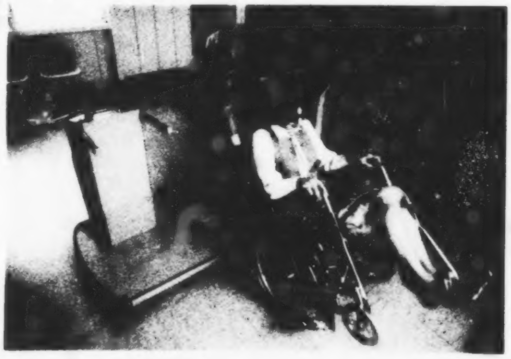
Schedule: June 1982 — December 1984

Funding: TDC —	$ 69,800
Roads and Transportation Association of Canada —	$ 50,000
Total —	$119,800

Project Number: 4712
File Number: D-1450-103-51
Project Officers: Trevor Smith, Catherine Hirou



Modular transfer vehicle



Integrated ramps allow for easy wheelchair access

Modular Transfer Vehicle Development

Description

Despite the increase in the complexity and size of modern passenger terminals (particularly in airports), they usually lack adequate facilities for disabled travellers. To overcome this deficiency, TDC recently supported the development of SCAT (small carrier for alternative transfer). SCAT, an electric modular vehicle, can transport disabled and elderly people, as well as children, within terminals and other large complexes.

Special benefits include the capacity to transport several passengers and their luggage, while requiring only one attendant. Furthermore, SCAT is the only vehicle of its kind accessible to wheelchairs, and as such, avoids the transfer of passengers in and out of wheelchairs within the terminal.

The contractor has designed and built several prototypical units, including:

- two motorized modules, and
- four platform modules that can be arranged in a train with a motorized unit or pushed separately.

All modules can carry wheelchairs, walking passengers, and baggage. Mechanical testing of the prototypes was followed by field evaluations in Dorval Airport, Montreal.

Progress to July 1984

Minor deficiencies identified during field testing of the prototype are being modified. A prototype of an outdoor model, with a more powerful motor and heavier tires, is now being built.

Contractors

Les Designers Douglas Ball Inc., Ste. Anne de Bellevue, Quebec
Rutenberg Design Inc., Dorval, Quebec

Report

Draft (TP 5818E), Modular transfer platform: development and evaluation, Les Designers Douglas Ball Inc.

Schedule: March 1983 — October 1984
Funding: TDC — $86,800

Project Numbers: 4934, 6268
File Number: D-1450-103-41-2
Project Officer: Dr. Ruth M. Heron

Vehicle Selection Guidelines

Description

Despite the growing availability of accessible public transportation services, the automobile is still the most convenient, versatile, and practical mode of transport for many elderly and disabled Canadians.

In this project, researchers are developing guidelines to help elderly and disabled drivers buy suitable vehicles and driving aids. The guidelines also will be helpful to the potential drivers among the estimated two million Canadians with disabilities that make driving difficult or impossible.

The project encompasses a survey of elderly and disabled drivers and potential drivers in Canada to determine their capabilities and limitations. International inventories are being compiled of personal mobility aids and adaptive automotive equipment, such as automobile control systems and wheelchair loading devices. A survey of production vehicles will be carried out to classify such features as head room, leg room, and storage space for a wheelchair or other mobility aids. In all, 170 car, van, and truck models will be profiled.

A vehicle comparison chart and a buyer's checklist will be developed to assist elderly and disabled drivers to match their needs to vehicles available in Canada.

Progress to July 1984

Technical work is nearing completion; a report is in preparation.

Contractor

James F. Hickling Management Consultants Ltd., Ottawa, Ontario

Report

Draft, Vehicle and equipment selection guidelines for disabled persons, James F. Hickling Management Consultants Ltd.

Schedule: April 1984 — January 1985
Funding: MSERD-E&H — $28,000

Project Number: 6112
File Number: D-1450-103-58
Project Officer: Barbara A. Smith

Field Evaluation of Quick-Release Hand Controls for Automobiles

Description

The demand for rented automobiles by disabled Canadians, for business and pleasure travel, has increased considerably. Fixed-equipment automobiles (dedicated for use by handicapped persons) are wasteful for the car rental concessionaire, because people who are not disabled prefer not to use them.

In an earlier project, TDC sponsored the development of a modified Wright-Way Inc. hand control that can be quickly installed and removed by the car rental concessionaire. The device was tested by disabled drivers in 1983, but insufficient information was collected. Consequently, TDC is supporting the continuation of long-term field tests to evaluate the ergonomic benefits of the device for disabled users and its suitability for concessionaires.

Progress to July 1984

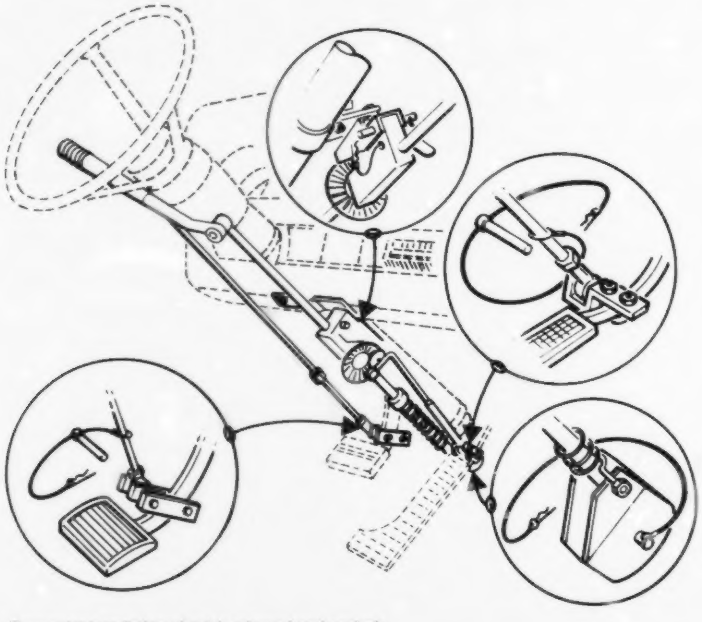
The device has been placed in test service with two rental car concessionaires in Ottawa and one in St. John's, Newfoundland.

Contractor

Davis Engineering Ltd., Ottawa, Ontario

Report

None to date



Four-point installation of quick-release hand controls

Schedule: March 1983 — November 1984
Funding: TDC — $25,000

Project Numbers: 4968, 6154
File Number: D-1450-103-42
Project Officer: Dr. Ruth M. Heron

Motorized Mobility Aids: Status and Safety Issues

Description

Since the early 19th century, wheelchairs have been used by people with limited mobility. In the late '50s and early '60s, technological improvements in motors and directional devices led to the electric wheelchair. Although this was a major breakthrough, the motorized wheelchair, like its manual counterpart, is heavy, cumbersome, and difficult to control. In addition, it requires daily battery recharging.

These shortcomings led to the development of a new generation of motorized wheelchairs designed to climb curbs, traverse rough terrain, and achieve greater speeds and distance. Configurations include a variety of two-, three-, and four-wheeled roadworthy vehicles.

With the proliferation of these vehicles, the lack of operating, licensing, and safety standards and the lack of consistent regulations have posed problems for operators and regulators alike.

In light of these problems, this project:

- surveys non-conventional wheelchairs and other motorized mobility aids;
- reviews national, provincial, and municipal regulations regarding their operation on roads and sidewalks; and,
- assesses problems associated with licensing, insurance, and safety.

The data will lead to a classification of vehicles and their appropriate operating environments. The need for national and provincial safety and licensing standards will be determined. Finally, recommendations will be made concerning manufacturing standards of motorized vehicles for operation by disabled persons.

Progress to July 1984

This project has just started.

Contractor

DeLeuw Cather Canada (DelCan) Ltd., Ottawa, Ontario

Report

None to date

Schedule: July 1984 — June 1985
Funding: MSERD-E&H — $29,900

Project Number: 6079
File Number: D-1450-103-58
Project Officer: Barbara A. Smith

Pedestrian Crosswalk Systems for the Elderly and the Handicapped

Description

Recent statistics show that Canada's highest pedestrian accident rate is among the elderly. The majority of these accidents happen at controlled intersections and at mid-block crosswalks.

Research indicates that these accidents are often associated with physiological changes due to aging, such as shrinking of the visual field; a decrease in hearing sensitivity; slowing down of reaction time; and an increasing tendency toward confusion, anxiety, and indecision.

Existing pedestrian crosswalk systems do not take into consideration the physiological characteristics of the elderly or the needs of disabled pedestrians. Disabled pedestrians include those with visual, auditory, and mobility impairments, as well as mental retardation.

This project involves classifying elderly and disabled pedestrians in terms of dysfunctions in order to develop basic user needs criteria. These criteria were the basis of a survey and evaluation of current crosswalk technology in Canada and abroad. Functional specifications for the ideal pedestrian crosswalk system, compatible with existing standards and traffic control technology, were then developed.

Progress to July 1984

Technical work has been completed; a report is in preparation.

Contractor

MANOP Services Ltd., Vancouver, British Columbia

Report

Draft (TP 4726E), Pedestrian crosswalk systems for the elderly and the handicapped, MANOP Services Ltd.

Schedule: March 1984 — February 1985
Funding: MSERD-E&H — $29,000

Project Number: 6101
File Number: D-1450-130-26
Project Officer: Barbara A. Smith

Transport Management Game

Description

Simulation games have proven to be an effective management training tool for the transportation industry. For example, the Transport Canada Training Institute (TCTI) has had positive feedback from students using "BusCompete," a simulation game developed by the World Bank in which six teams operate competing bus companies. The success of "BusCompete" has prompted interest in the development of a multimodal simulation exercise involving bus, rail, and air transportation.

The objective of this project is to develop a simulation game on an Apple IIe microcomputer that includes the three modes in a realistic Canadian context. TDC and the Université de Montréal are developing this management game for TCTI.

The game is designed to be played by six players or teams, each of whom manages one passenger transportation company. At the start of the game, players receive operational and financial reports of their company as well as general socio-economic information. Based on these data, players make a number of decisions (services, schedules, rates, purchases, etc.) that will have a direct impact on their company's performance in the following year. At the end of each cycle (year), players receive a status report describing the changes in their company as a result of both their decisions and the decisions of the other players. They also receive a new list of decisions to be taken for the coming year. As the game continues through successive cycles, players must try to improve their company's position with each set of decisions.

Progress to July 1984

The first version of this game is being shaped. The game will be ready for testing at TCTI in October 1984. Improvements and revisions will be done subsequently, and the second version will be tested in spring 1985.

Contractor

Centre de recherche sur les transports, Université de Montréal, Montreal, Quebec

Report

None to date

Schedule: September 1983 — April 1985

Funding: TDC —	$25,000
TCTI —	$30,000
Total —	$55,000

Project Numbers: 6077-78, 6272-73
File Number: D-1450-145
Project Officer: Catherine Hirou

Application of Fuzzy Sets to Risk Assessment

Description

Hazards connected with the transportation of dangerous goods have become a matter of public concern in recent years. The risks to which the public is exposed need to be measured. Safety improvements achievable through new legislation also need to be assessed.

Most risk analyses evaluate the relative probability of various types of accidents and the likely damage. In many cases the probability is small, even though the damage caused can be significant. Although the purpose of these analyses is to provide an objective evaluation of the risks involved; in practice they involve subjective judgements at several points.

In recent years a methodology has been developed to handle vague or ambiguous concepts for application in human decision-making processes. Since its conception, this approach, described as fuzzy set or possibility theory, has helped in the formulation of many operations research models.

Fuzzy set theory, as applied to risk, measures perception and acceptability of risks through surveys of individual attitudes. These surveys can be applied to either knowledgeable individuals, such as those involved in operating a transportation system, or to the general public.

As fuzzy set theory has not been extensively applied to risk assessment and management, it needs to be developed further in order for it to be considered one of the standard methodologies in this field. This project is testing the fuzzy set theory alongside the probabilistic approach in a specific test application.

If the application of the fuzzy set theory to the measurement of hazard perception proves to be successful, it will be useful in the evaluation of safer transportation methods for hazardous goods.

Progress to July 1984

At the midway point in the research, it appears that fuzzy set theory may facilitate the inclusion of public perception of risk acceptability in the evaluation of methods of transporting dangerous goods.

Contractor

IBI Group, Toronto, Ontario

Report

None to date

Schedule: March 1984 — January 1985

Funding: TDC —	$ 45,000
Transport Canada — Dangerous Goods Branch —	$ 50,000
DSS —	$ 51,500
Total —	$146,500

Project Numbers: 6156-7-8
File Number: D-1465-374-3
Project Officer: Barry B. Myers

Transportation Safety: an R&D Planning Framework

Description

The objective of this project was to develop a systems safety methodology, applicable to all transportation modes, which would help to establish research and development needs and provide a measure of the safety improvements achievable through technology R&D and other system changes.

An earlier TDC study on the costs of aviation accidents concluded that little substantive research is available on systems safety methodology. As a result, this present project was undertaken to provide Transport Canada with a structured approach to setting safety objectives, allocating R&D funds to safety programs, and evaluating the effectiveness of such programs.

This project included a review of transportation safety management for all modes to identify current safety programs, philosophies, measurement criteria, and methods used to determine safety R&D activities.

Work was restricted to the investigation of those safety elements involving vehicles, drivers, passengers or cargo, and service operations, maintenance, and training.

In the report, researchers proposed a method of safety R&D planning based on work conducted by Battelle Columbus Laboratories for the United States Coast Guard. The potential usefulness of this approach was demonstrated by performing a sample safety problem analysis in the air mode. The report concluded that the Canadian Air Transportation Administration would be an appropriate starting point for a pilot implementation of the proposed planning framework.

Progress to July 1984

This project has been completed.

Contractor

Peat, Marwick and Associates Ltd., Montreal, Quebec

Reports

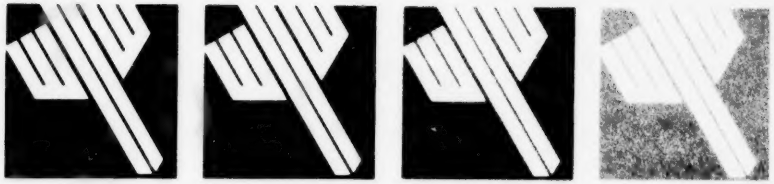
TP 5045E, Transportation safety: a framework for R&D planning, Peat, Marwick and Associates Ltd., 1983.

TP 5046E, Transportation safety: a framework for R&D planning, summary report, Peat, Marwick and Associates Ltd., 1983.

Schedule: November 1982 — December 1983
Funding: TDC — $97,500

Project Number: 4557
File Number: D-1450-126
Project Officer: Barry B. Myers

AIR
TECHNOLOGY



Air Technology

Transport Canada's Canadian Air Transportation Administration is responsible for the national air transportation system and for ensuring its safe and efficient operation. This responsibility, which embraces regulatory and operational functions and the provision of facilities, calls for the support of research and development to increase effectiveness and to ensure safety. As well, the vast extent of Canadian air space generates R&D opportunities in the fields of electronics and air traffic control equipment.

TDC is stimulating and providing research and development in support of Transport Canada's needs and in cooperation with operating and equipment manufacturing industries. This is helping Canada obtain an important market share in worldwide aeronautical technology through such specialized products as small gas turbine engines, turboprop STOL aircraft, specialty components, aircraft simulators, and sophisticated aeronautical test facilities and services.

SAFETY & REGULATION

An important concern of TDC's air technology program is the improvement of safety and security standards in the Canadian air transportation environment. TDC is working with the Canadian Aviation Safety Board and the air regulations branch to realize this objective. Planning tools are being developed to forecast future system needs or equipment capabilities and to identify research requirements.

The cockpit and passenger cabin environment as well as crew workload characteristics are being researched to assess how accident risks can be reduced and survival rates increased. Other research involves the preparation of a manual to help accident investigators analyze light bulb filaments.

NAVIGATION & AIRPORTS

TDC's research in this area is concerned with the operational aspects of air transportation. Research in navigation aids is intended to increase operational safety and efficiency. In the area of airport research, TDC's activities are aimed at the development of design and planning concepts that would increase the capacity, efficiency, and productivity of airports and associated systems.

AIRFRAME & PROPULSION

This third area of research encompasses TDC's support of Canadian air industry in the design of innovative aircraft and engines. TDC support helps to reduce the risk level of these advanced-technology research activities. Devices, components, and materials that can improve design and operation for aircraft are being investigated and developed.

Research in the area of aircraft engines is primarily concerned with improving the energy efficiency of Canadian-built engines.

Smoke Mask Criteria

Description

Although air passenger safety technology has advanced significantly in the past decades, it needs to be developed to a more sophisticated level. In particular, the problem of passenger escape from an aircraft filled with smoke and toxic gases has not been satisfactorily addressed. The recent Air Canada DC-9 disaster in Cincinnati, where 23 of the 46 passengers and crew died, brought this problem to our attention once again.

A number of protective smoke masks have been developed to try to alleviate the effects of toxic fumes resulting from onboard fires. However, there are still questions that need to be answered before these devices can be fully assessed:

- How rapidly is oxygen in the cabin displaced?
- How long does it take for carbon monoxide and other gases to reach toxic levels?
- What is the mean and standard deviation of human tolerance to radiant heat?

This study is addressing these questions. In particular, it will produce a set of specifications for a suitable smoke mask for air passengers. These criteria will be set through literature reviews (including accident reports) and discussions with persons in the field of aviation medicine. An analysis of factors such as type of aircraft, cause and duration of fire, and number of fatalities will be conducted. In addition, laboratory tests of existing smoke masks will be undertaken to determine which, if any, meet the necessary criteria.

If none of the existing smoke masks is found suitable, the development of a new mask will be recommended.

Progress to July 1984

This project has just started.

Contractor

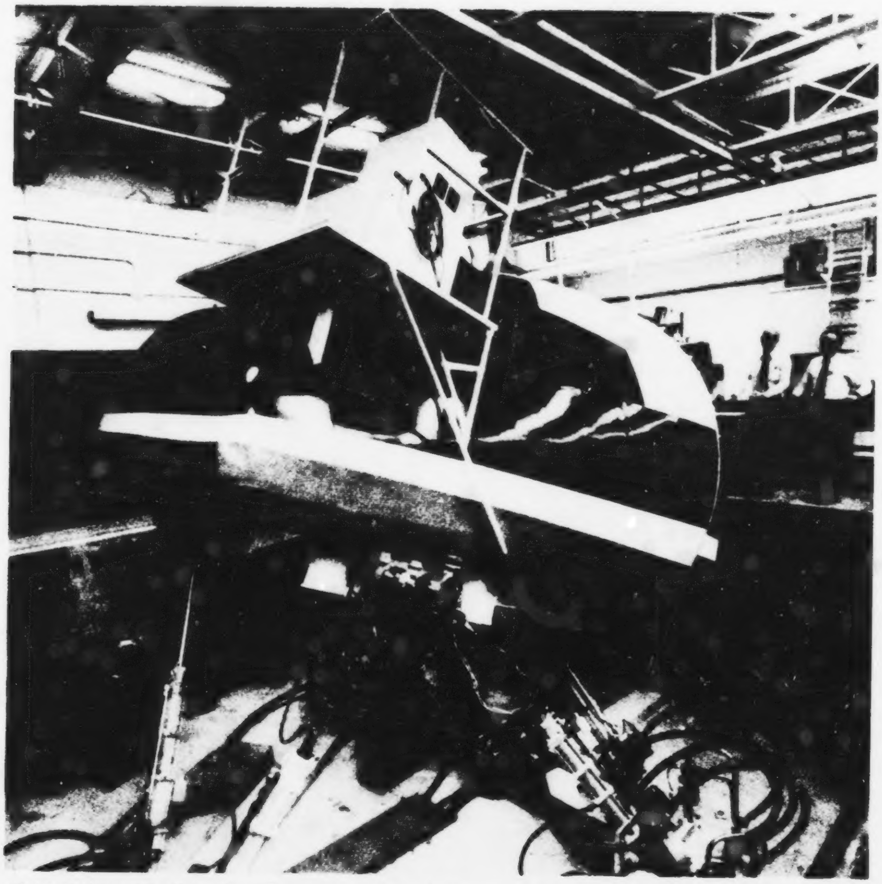
Ontario Research Foundation, Mississauga, Ontario

Report

None to date

Schedule: March 1984 — November 1985
Funding: TDC — $84,400

Project Number: 6206
File Number: D-1455-1
Project Officer: Dr. Ruth M. Heron



Flight simulator at the University of Toronto's Institute for Aerospace Studies

Aircraft Simulator Response

Description

Aircraft simulation plays an important role in commercial and military aviation as it is an effective and cost-efficient training tool.

In order for a simulator to be truly effective, it must be able to reproduce the physical environment of a given aircraft (objective fidelity), as well as recreate the experience of flight (perceptual fidelity). Although considerable advances have been made in achieving objective fidelity, there are still a number of problems in achieving perceptual fidelity.

One problem relates to a trainee's perception of motion. Many aircraft simulators use a synergistic motion base having six hydraulic jacks with hydrostatic bearings. However, as the motion of the simulator base is necessarily limited, the motion cues it provides to a trainee fall short of those experienced in flight. To overcome this problem, use is made of computer software linking the motion base to aircraft flight equations.

This study is investigating three different motion base controllers. The first system, used with civilian flight simulators, combines linear high-pass washout filters with tilt coordination. Some lack of fidelity results, however, as the same degree of signal attenuation is used to control excessive movement of the jacks.

Two other types of control are possible: adaptive filters, which take into account how close the jacks are to their travel limits at a given moment; and optimal control, which operates according to an optimization of certain motion features specified by the simulator designer.

In this study, computer algorithms for the three types of motion base controllers are being developed. Hardware and software will then be developed to provide a simulator and a set of flying tasks suitable for testing algorithm effectiveness.

In the main experiment, qualified flight crew will evaluate the performance of the simulated flight tasks to derive specifications of best parameter values for each type of controller and compare relative effectiveness.

Progress to July 1984

The adaptive and optimal controller algorithms have been completed. The motion sensor package is currently being installed in the cab of the simulator and relevant software will be developed. Tests will then be run to determine the proper functioning of the system.

Contractor

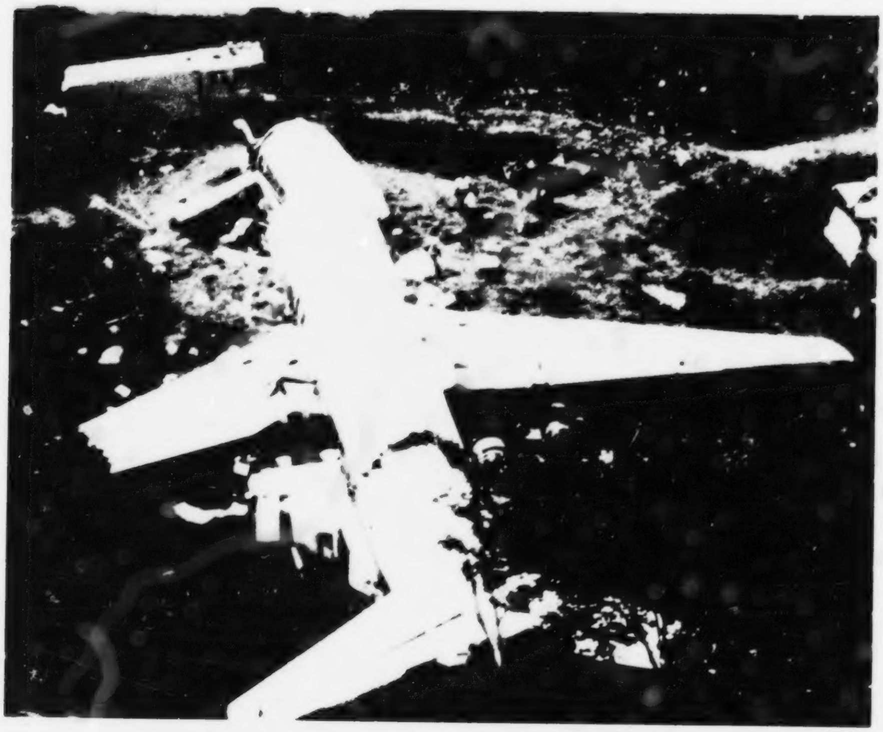
University of Toronto, Institute for Aerospace Studies, Toronto, Ontario

Report

None to date

Schedule: October 1983 — December 1986
Funding: TDC — $290,000

Project Number: 6069
File Number: D-1455-155
Project Officer: Dr. Ruth M. Heron



Light Bulb Filament Impact Dynamics

Description

Aircraft accident investigators analyze light bulb filaments to infer the state of electrical circuits and failure warning lights at the moment of a crash. The condition of the bulb on impact (if it was "warm," "on," or "off") helps investigators to pinpoint system failures.

Since 1966, accident investigators have relied on a manual of light bulb analysis published by the Royal Canadian Air Force. TDC has sponsored the development of a new manual that will provide field and laboratory workers with current research on filament behaviour under different impact conditions. This important reference will have worldwide applications; it is to be included in the corresponding manual of the International Civil Aviation Organization (ICAO).

In support of the manual's preparation, TDC has funded a multi-year program to study and test filament fracture theory in cooperation with the Aviation Safety Engineering (ASE) division of Transport Canada. ASE contributed physical facilities and equipment (e.g., impact test machines, high-speed cameras, and electron microscopes) to the project.

Researchers have completed preliminary studies, generated a mathematical model of filament behaviour, and conducted intensive testing. Test results have already been used in the course of several air accident investigations.

Progress to July 1984

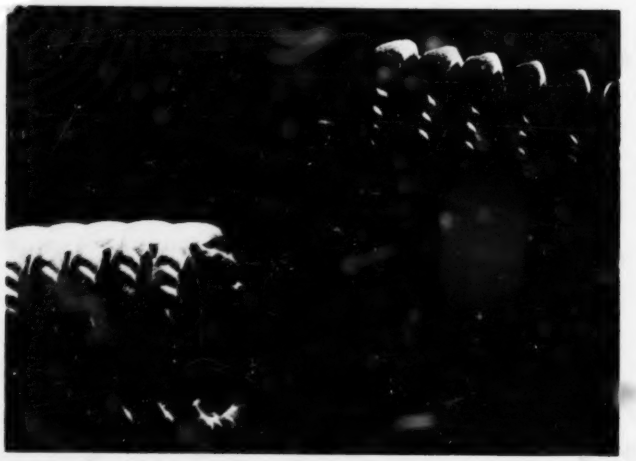
Technical work has been completed; a report is in preparation.

Contractor

Transport Canada, Aviation Safety Engineering, Ottawa, Ontario

Report

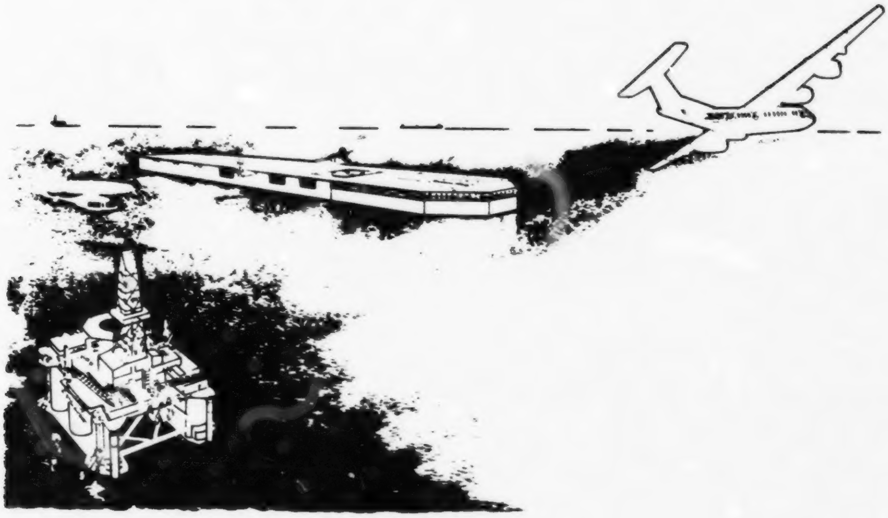
None to date



Typical filament burn-out resulting from aging and over-voltage

Schedule: January 1980 — November 1984
Funding: TDC — $160,000
ASE — supervision and capital equipment

Project Number: 4028
File Number: D-1455-129
Project Officer: Barry B. Myers



Artist's concept of floating STOLport barge

Offshore Air Terminal

Description

Transporting people and materials to and from offshore oil sites can be a problem in the severe climatic conditions off the coast of eastern Canada. This project examined ways of developing safe and efficient transportation systems for Canadian offshore oil resource development facilities. The study concentrated on three offshore sites: The Labrador Sea, Newfoundland Offshore (Hibernia), and the Scotian Shelf (Sable Island).

The study examined the existing direct helicopter service along with a number of systems that could improve the transfer of personnel between supply bases and offshore drilling platforms. These included:

- fixed offshore heliports,
- floating heliports, and
- floating STOLports.

The study concluded that many of the current transportation problems could be improved by more advanced helicopter technology and more efficient support services. The greatest potential for improvement, however, is to introduce fixed-wing STOL aircraft operating between land and offshore floating airports.

A number of methods were examined and although all were technically feasible, their high capital costs offset the potential savings from reduced aircraft operating costs. Some of the floating STOLport barge concepts could be economically justified if these barges could be used for crude oil storage.

Other concepts studied included tilt wing/rotor aircrafts that have the higher en-route speed of fixed-wing aircraft and the vertical take-off and landing capabilities of helicopters. These aircraft are being tested by the U.S. military, but considerable research still needs to be done to determine their application for civilian use.

Progress to July 1984

This project has been completed.

Contractor

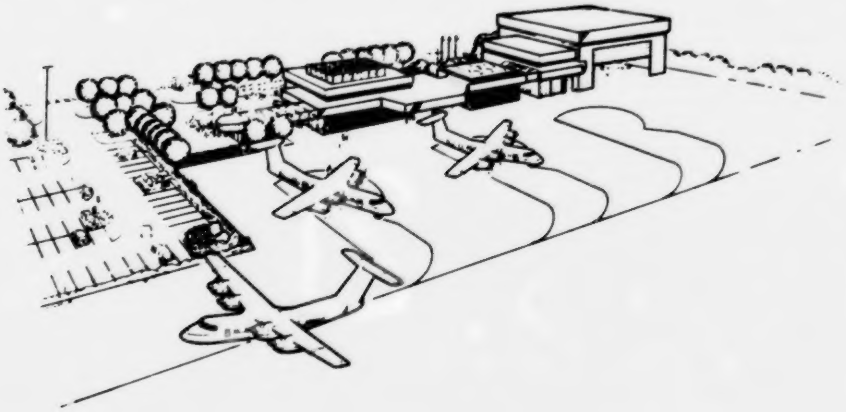
IBI Group, Toronto, Ontario

Reports

TP 5047E, Offshore airport concepts servicing the East Coast energy resource industry, main report, IBI Group, 1983.
TP 5048E, Offshore airport concepts servicing the East Coast energy resource industry, summary report, IBI Group, 1983.

Schedule: May 1982 — October 1983
Funding: TDC — $ 60,000
Transport Canada Energy
Program — $140,000
Total — $200,000

Project Number: 4610
File Number: D-1455-144
Project Officer: Barry B. Myers



Artist's drawing of a STOLport design

STOLport Design Research

Description

Canada's first commercial STOL service between Toronto, Ottawa, and Montreal will be operational in September 1984. This project involved preparing specific recommendations and conceptual design drawings for STOLport facilities at the three sites.

Work was conducted in two stages:

- the identification of generalized requirements for private commuter STOL facilities; and
- site application of the generalized standards to the three specified airports.

In Ottawa, the STOL operation will be integrated with a national aviation museum that is being planned next to Rockcliffe Airport. Having an integrated STOLport operation adjacent to this museum would be a living example of Canadian aviation heritage.

The Victoria STOLport in Montreal has been unused since 1976 and therefore needs considerable refurbishing. The required facilities will be constructed on existing building foundations.

At Toronto Island Airport, which is owned and operated by Transport Canada, the STOL operator will be responsible for providing the auxiliary terminal and support facilities required for the STOL service.

Progress to July 1984

Technical work has been completed; a report containing recommended guidelines for STOLport facilities is in preparation.

Contractors

IBI Group, Toronto, Ontario
Canavia Transit/City Center Airways, Toronto, Ontario

Report

Draft (TP 5986E), STOLport research and applications, IBI Group.

Schedule: September 1983 — January 1985
Funding: TDC — $28,000

Project Number: 6091
File Number: D-1455-101-18
Project Officers: Trevor Smith, Catherine Hircu

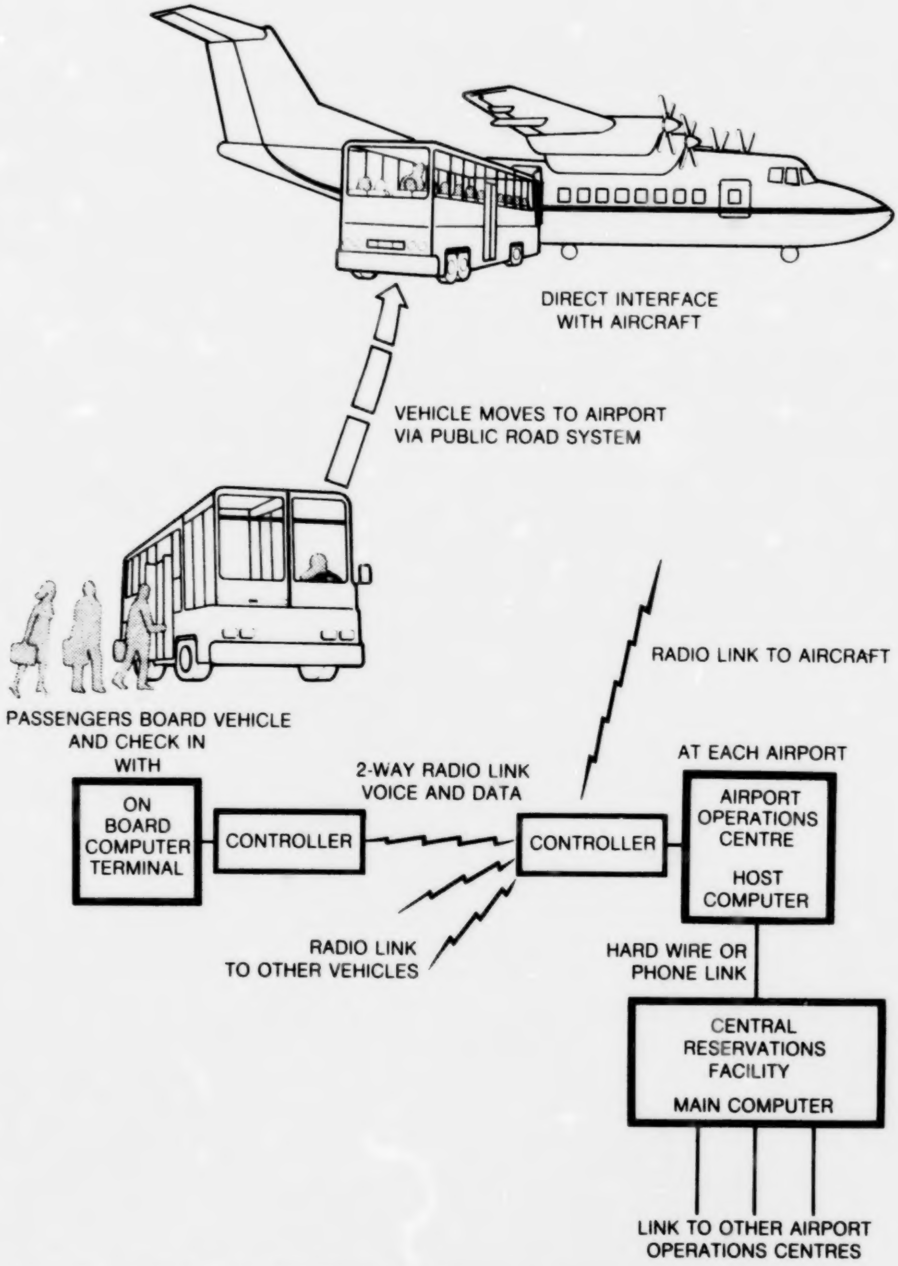

DIRECT INTERFACE WITH AIRCRAFT
VEHICLE MOVES TO AIRPORT VIA PUBLIC ROAD SYSTEM
RADIO LINK TO AIRCRAFT
PASSENGERS BOARD VEHICLE AND CHECK IN WITH
AT EACH AIRPORT
2-WAY RADIO LINK VOICE AND DATA
ON BOARD COMPUTER TERMINAL
CONTROLLER
CONTROLLER
AIRPORT OPERATIONS CENTRE
HOST COMPUTER
RADIO LINK TO OTHER VEHICLES
HARD WIRE OR PHONE LINK
CENTRAL RESERVATIONS FACILITY
MAIN COMPUTER
LINK TO OTHER AIRPORT OPERATIONS CENTRES

Illustration of the mobile air terminal concept using a special-purpose ground vehicle

Mobile Air Terminal

Description

An integrated air and ground transportation service would be time-saving and convenient, particularly for business travellers who generally take day trips and carry little luggage. This project is addressing the conceptual design of a purpose-built ground transport vehicle that would transport passengers to and from a city centre and an airport.

An integrated air and ground transportation service was recently demonstrated in Toronto: an Orion 35' bus carried travellers from the downtown Royal York Hotel to Toronto Island Airport, across the ferry. Total travelling time from bus boarding to take-off was less than 20 minutes.

The success of this demonstration brought to light three additional possibilities for improvements in an integrated air and ground transportation service:

- information and check-in facilities on the bus, eliminating check-in at the terminal;
- a physical connection between the vehicle and the aircraft to protect passengers from adverse weather conditions; and
- an improved baggage handling system that could reduce delays as well as personnel.

The project will study this concept of a mobile air terminal in terms of feasibility, market requirements, and operational specifications for the vehicle. Conceptual designs will be developed for the processing and communications system as well as the actual vehicle.

Progress to July 1984

Work on the market potential and operational specifications has been completed. Although emphasis has been placed on developing specifications for a comprehensive mobile air terminal, variations employing fewer features of the vehicle may also be possible where market conditions might not warrant the costs associated with the full system. Features that might be considered optional include: direct connection to the aircraft, mechanized baggage handling, and communications and dispatch capability.

Contractor

IBI Group, Toronto, Ontario

Report

Draft (TP 5985E), Mobile air terminal concept, IBI Group.

Schedule: March 1984 — February 1985
Funding: TDC — $28,000

Project Number: 6183
File Number: D-1455-101-18
Project Officers: Trevor Smith, Catherine Hirou

Microwave Landing System Antenna Development

Description

The microwave landing system (MLS) will become the prime aircraft landing system by 1995, replacing the present International Civil Aviation Organization standard UHF/VHF instrument landing system (ILS).

The MLS will provide aircraft with precision approach and landing capability through the use of sophisticated microwave and computer technology. The MLS is more accurate than the ILS, extending flight coverage 40° in azimuth and 15° in elevation, with greater freedom from signal distortions by terrain irregularities and adverse weather conditions.

The MLS will allow pilots to make smooth, direct approaches, saving time and fuel. Furthermore, it will enable airports in mountainous regions, on oil rigs, and other difficult locations to be served by a precision landing system for the first time.

The objective of this project was to support the deployment of MLS by developing a 40° sweep, slotted waveguide azimuth antenna to be integrated with the control electronics. After completing the preliminary design of an MLS azimuth antenna, researchers fabricated, evaluated, and redesigned the key subsystem elements.

A prototype azimuth antenna was constructed, then integrated with control electronics and a microwave source.

Excellent results were obtained during ground and flight testing of the antenna system. The tests also confirmed compatibility of the system with standard international avionics receiving equipment.

Progress to July 1984

This project has been completed.

Contractor

Micronav Ltd., Sydney, Nova Scotia

Reports

TP 5519E, Microwave landing system azimuth antenna subsystem, Micronav Ltd., June 1984.

TP 5520E, Microwave landing system azimuth antenna subsystem, summary report, Micronav Ltd., June 1984.

Schedule: March 1983 — June 1984
Funding: TDC — $300,000

Project Numbers: 4880, 4977
File Number: D-1455-153
Project Officer: Micha Avni

Cycle Charged Diesel Power Supply

Description

Remote aeronautical hazard beacons have long been recognized as a practical navigational aid. For example, they are used by Transport Canada's Air Administration for night operations at airports surrounded by high terrain. Because the conventional electrical cable, or powerline, required for each beacon is extremely costly, TDC is sponsoring investigation of independent power sources.

The beacons are usually set on remote mountainsides accessible only by helicopter. Power sources must therefore be transportable by air and function for extended periods without refuelling, recharging, or maintenance.

The Cycle Charged Diesel (CCD) was selected from other possible power sources as a promising means of obtaining a reliable power source for remote locations. In this TDC project, researchers have developed, built, and tested two prototype CCD power supply systems with backup, to supply power to aeronautical hazard beacons of 40-100 W.

The CCD prototypes were installed at Grande Cache, Alberta, for one year of operational testing. A number of improvements were identified as a result of this testing, particularly in the area of circuitry control and the environmental packaging of the unit. The implementation of these improvements is being considered currently.

Progress to July 1984

Technical work has been completed; a report is in preparation.

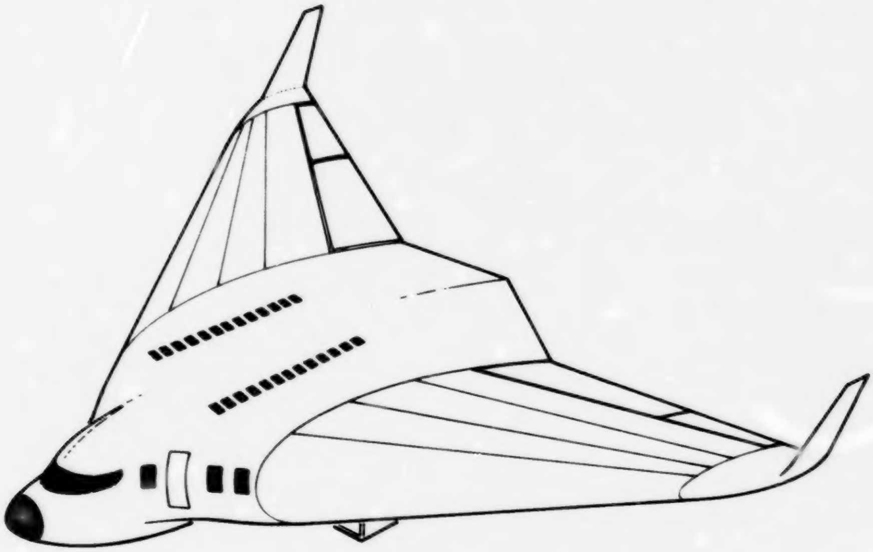
Contractor

Mechron Energy Ltd., Ottawa, Ontario

Report

Draft (TP 5854E), Cycle charged diesel power system for remote hazard beacons, Mechron Energy Ltd.

Schedule: March 1983 — September 1984		**Project Number:** 4857
Funding: TDC —	$115,700	**File Number:** D-1455-126
CATA (Western Region) —	$ 27,000	**Project Officer:** Micha Avni
Total —	$142,700	



The "flying wing" design of a 100-passenger aircraft

AIRFRAME & PROPULSION

Innovative Aircraft Configurations

Description

In 1979, Canadair made detailed studies of increased fuel efficiency deriving from composite materials, advanced propulsion systems, and modified wing configurations. Canadair produced experimental work on wing aerodynamics in 1980 and designed an energy-efficient, conventionally configured small transport aircraft in 1981.

In this series of energy-efficiency studies, Transport Canada sponsored research into an unconventional aircraft configuration. The "flying wing" design was examined for practical application on transport aircraft carrying 50-100 passengers.

After studying data on "flying wings," Canadair compared the all-wing concept with a previously studied conventional 70-passenger aircraft with a 2200 nautical mile stage length. Researchers examined layout and structural possibilities; analyzed aerodynamics, control, and handling; determined field and climb performance; and, conducted mission analyses.

Results of this analytical study indicated that the conventional wing-body-tail configuration operated more efficiently and used less fuel than the all-wing design. However, given shorter stage lengths and high enough thrust-to-weight ratios and climb speed, the "flying wing" showed improvement over the conventional configuration. Layout problems with the all-wing concept led to the selection of a blended wing-body design. Researchers predicted this configuration will be advantageous when applied to a larger aircraft with increased passenger capacity.

Canadair researchers found that passenger capacity could be raised by extending the cabin along the span of the wing. They concluded that a large aircraft would operate more efficiently than the small transport configuration owing to higher wing loading values, lift coefficient, lift/drag ratio, and aspect ratio.

Progress to July 1984

Technical work has been completed; a report is in preparation.

Contractor

Canadair Ltd., Montreal, Quebec

Report

Draft, An investigation of the feasibility of an all-wing passenger transport, Canadair Ltd.

Schedule: November 1982 — July 1984
Funding: TDC — $ 76,500
Transport Canada Energy Program — $100,000
Total — $176,500

Project Number: 4801
File Number: D-1455-112-5
Project Officer: Barry B. Myers

DASH 7

Fuel-Efficient STOL Aircraft

Description

In 1977, de Havilland Aircraft of Canada conducted a parametric study which showed that new technology could significantly improve the fuel efficiency of short take-off and landing (STOL) aircraft. This finding resulted in the creation of a four-phased research program to establish a data base for the design of fuel-efficient STOL aircraft.

Initial phases of this project involved the design and testing of a slotted aileron with a 14%-thick airfoil using a leading edge slot to improve maximum lift and control effectiveness. The significant gains achieved in the tests can result in reduction of the size of wings and the size and complexity of flap systems or ailerons.

In other research conducted under this program, a propeller-tip airfoil of 4% thickness was tested and found to reduce low drag as a result of extensive laminar flow and low shock losses.

Phase four of this research program is concentrating on improving the fuel efficiency and reducing the operating cost of STOL aircraft. A parametric study of aircraft performance will be conducted to compare new and old technology. As well, detailed component studies will be conducted involving the design, fabrication, and tunnel testing of a slotted aileron model and an exhaust/wing configuration model.

Progress to July 1984

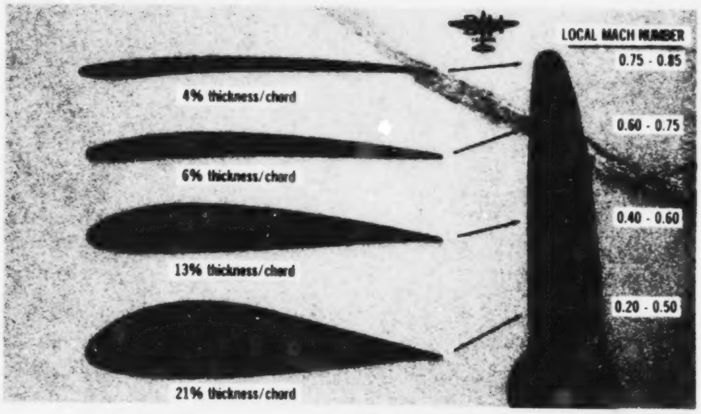
This project has just started.

Contractor

de Havilland Aircraft of Canada Ltd., Toronto, Ontario

Report

None to date



Propeller airfoil design — one element of the STOL aircraft research program

---

Schedule: May 1984 — February 1986

Funding: TDC —	$185,200
Transport Canada Energy Program —	$200,000
Total —	$385,200

Project Numbers: 6210-1
File Number: D-1455-112-6
Project Officer: Barry B. Myers

Mixed Flow Turbine Study

Description

In the late '70s, TDC sponsored studies into the energy efficiency of turboprops and turbofans and the potential for improvements over a ten-year period. This research indicated that a mixed flow turbine promised to be more fuel-efficient by combining the high efficiency of the radial design with the low weight of the axial flow turbine.

In this project Pratt & Whitney Canada Inc. designed and tested mixed flow turbines with an efficiency goal of 87%. They investigated three hardware configurations: a 14-blade rotor with 10° incidence, a 14-blade rotor with 20° incidence and an 18-blade rotor with 20° incidence. Varying clearances and different nozzles indicated optimal loading levels of each configuration.

A new procedure to complete the aerodynamic optimization of the rotors was designed. It favoured a two-section design for good control over the leading edge metal angle distribution. For engine applications, researchers suggested that hub and tip metal angles be adjusted to minimize leading edge overspeeds. Favourable pressure gradients, caused by radius changes, allow higher Mach number diffusions. Curvature modifications overcame problems of channel convergence near the leading edge, and analysis programs predicted lower deviations for sections of low uncovered turning. Aerodynamic analyses of the test rotors indicated that even higher efficiencies may be expected.

Progress to July 1984

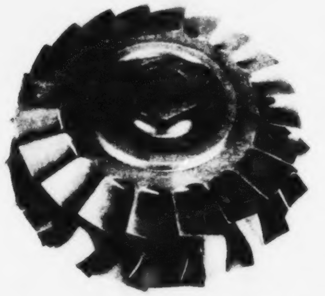
Technical work has been completed; a report is in preparation.

Contractor

Pratt & Whitney Canada Inc., Longueuil, Quebec

Report

Draft, Aerodynamic design of three mixed flow turbine rotors, Pratt & Whitney Canada Inc.



Mixed flow turbine rotor

Schedule: April 1983 — October 1984

Funding: TDC —	$345,000
Transport Canada Energy Program —	$150,000
Pratt & Whitney Canada Inc. —	$125,000
Total —	$620,000

Project Numbers: 4884, 4885
File Number: D-1455-112-7
Project Officer: Barry B. Myers

Gas Turbine Ceramics Technology

Description

Ceramics can reduce the weight and specific fuel consumption of aircraft engines. Recent successful use of ceramic technology in missiles and ground-based turbines led to a new design for a ceramic-lined shroud for gas generator turbines that will increase turboprop and turbofan fuel efficiency.

Pratt & Whitney Canada Inc. estimated a fuel savings of 1.25% based on this design, a significant improvement compared with potential savings achieved through aerodynamic changes. Hot-engine tests, however, yielded measured improvements of 1.5%. Researchers then modified the shroud design to reduce blade tip losses and permit fuel consumption savings of 2% or better. Further fuel savings were predicted by the use of ceramics for nozzle vane rings and face rings.

Progress to July 1984

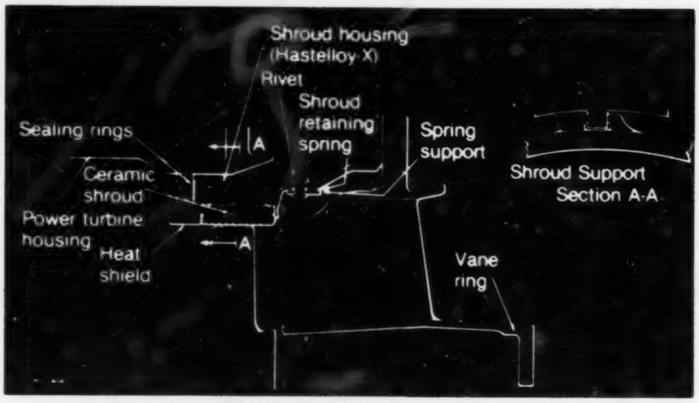
Further tests of the ceramic turbine shroud confirmed reductions in specific fuel consumption found in the hot-engine tests. Researchers recommended the application of ceramics to other turbine components. Current work involves implementing modifications to the ceramic shroud design and testing a PT6-A135/3 engine with the shroud installed. In addition, a ceramic nozzle vane ring and a ceramic face ring are scheduled for design and testing.

Contractor

Pratt & Whitney Canada Inc., Longueuil, Quebec

Report

None to date



Ceramic shroud and surroundings

Schedule: November 1982 — April 1985

Funding: TDC —	$100,000
Transport Canada Energy Program —	$ 40,000
Pratt & Whitney Canada Inc. —	$100,000
Total —	$240,000

Project Numbers: 4724, 6146
File Number: D-1455-112-1
Project Officer: Barry B. Myers

Advanced Propeller Designs

Description

The cost of fuel dominates the economics of civil air transportation. As fuel is the largest cost component in aircraft operations, the aviation industry is reconsidering the use of turbo-propeller propulsion for short-haul, low demand routes currently serviced by small jets and commuter aircraft.

In this project, the contractor first reviewed propeller design trends and developments by assessing recently completed and continuing propeller research programs of NASA and the major U.S. manufacturers (Dowty-Rotol, Hamilton Standard, Hartzell, and MacCauley). Consultations with Canadair, de Havilland, and Pratt & Whitney Canada generated reference aircraft configurations representing current products. The contractor then chose propeller propulsion systems for each configuration, and optimized the aircraft/propulsion design. The optimum and reference configurations were compared to establish improvements achieved in weight, payload, fuel consumption, capital and direct operating costs, and noise. Based on the research results, the contractor has recommended a development program in turbo-propeller propulsion for the Canadian aircraft industry.

Progress to July 1984

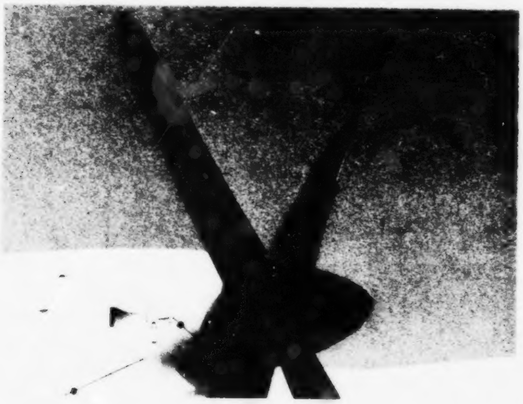
Technical work has been completed; a report is in preparation.

Contractor

Aercoustics Engineering Ltd., Toronto, Ontario

Report

None to date



Schedule: March 1983 — October 1984

Funding: TDC —	$ 25,000
Transport Canada Energy Program —	$ 25,000
DSS —	$ 70,000
Total —	$120,000

Project Number: 4862
File Number: D-1455-147
Project Officer: Barry B. Myers

MARINE
TECHNOLOGY

Marine Technology

Canada's unique marine environment provides ample R&D opportunities to develop technology specially tailored to operations in ice-covered and ice-infested waters. The focus of TDC's marine technology R&D program continues to be on arctic and sub-arctic navigation, vehicles, and equipment; the ultimate goal being year-round navigation. Sustained year-round operations will not only benefit Canada's current arctic operations, but will also facilitate future exploitation of oil and gas reserves in the north.

In more conventional applications, Canada's marine environment needs to be documented and the data translated into appropriate designs, operating methods, and regulatory framework.

To ensure that Canadian ports remain competitive with other world class ports, TDC is supporting technology development and demonstrations to accelerate the equipping of Canada's ports with high productivity facilities and services. R&D in marine navigational aids is seen by TDC as representing an evolving set of opportunities for the development of new equipment and components eventually benefiting both the shipping and the electronics industries.

ARCTIC MARINE TECHNOLOGY

TDC is supporting research in a number of areas in order to contribute towards a safe and efficient year-round navigation capability in arctic waters. This research is aimed at:

- providing a scientific basis for design and operating criteria applicable to regulations governing navigation in arctic waters;
- obtaining technical and environmental data and developing new technological concepts necessary to ensure reliable and efficient navigation services to arctic shipping;
- fostering the development of improved marine vehicle transportation systems capable of year-round arctic operations through R&D in hull, propulsion, and auxiliary system technologies; and,
- promoting the development and testing of new and more efficient harbour ice management techniques aimed at improving access to and the safe operations of Arctic marine terminals.

GENERAL ICE RESEARCH

TDC extends its commitment to improving marine navigation to other ice-covered waters. As with arctic research, TDC supports the development of shipboard instrumentation that will permit extension of the shipping season in sub-arctic regions. Research is also being conducted on an advanced ice hazard detection and collision avoidance system, with particular attention to iceberg detection techniques. In addition, TDC is fostering the advancement of marine vehicle technologies offering improved seakeeping and seaworthiness performance in Canadian east coast waters. Another objective of the general ice research program is to develop new, more efficient ice management techniques in sub-arctic regions, particularly in harbours, inland waters and rivers, to enable extended or year-round operations.

GENERAL MARINE RESEARCH

TDC is also involved with general marine technology research in more southern latitudes, including the West Coast, the Great Lakes, the St. Lawrence, and the Maritimes. For example, TDC is supporting the investigation of commercially available computer programs for use in developing dynamic stability criteria for small marine vessels. As well, TDC is committed to advancing the efficiency and performance capabilities of government-owned and commercial vessels and marine structures operating at or from Canadian terminals and navigating in southern Canadian and international waters. To this end, TDC is supporting the development of advanced, more efficient propulsion plants as well as continuing the development of a hydrostatic stern tube bearing. In addition, TDC is looking to improve the productivity and cost effectiveness of Canadian marine terminals through the application of engineering, material handling, and operational developments.

M.V. *ARCTIC* Scientific Program

Description

This joint government/industry scientific program began in 1975 with the construction of the Ice Class II bulkcarrier M.V. *Arctic*. The vessel was instrumented extensively to collect technical and operational performance data over several arctic shipping seasons with a view to improving the design, performance, and safe operation of ice transiting ships.

The detailed analysis of the collected data was divided among five projects:
- icebreaking (continuous mode),
- icebreaking (ramming mode),
- manoeuvering,
- propulsive performance, and
- structural performance.

The last phase of the program will be completed in the spring of 1985 with the preparation of a summary report bringing together the principal findings of the five data analysis projects, with particular reference to the interests of regulators, designers, builders, and operators of arctic class vessels.

Progress to July 1984

Analysis of the vessel propulsive performance, main machinery, gear train, shafting, and propeller with respect to ice-ingestion has been completed. Ice transiting performance (ramming and continuous modes) is in the final stage of report preparation. The detailed analysis of manoeuvering performance, turning circle, and directional stability in ice is expected to be completed by November 1984, and the analysis of structural performance is expected to be completed in the spring of 1985.

Contractors

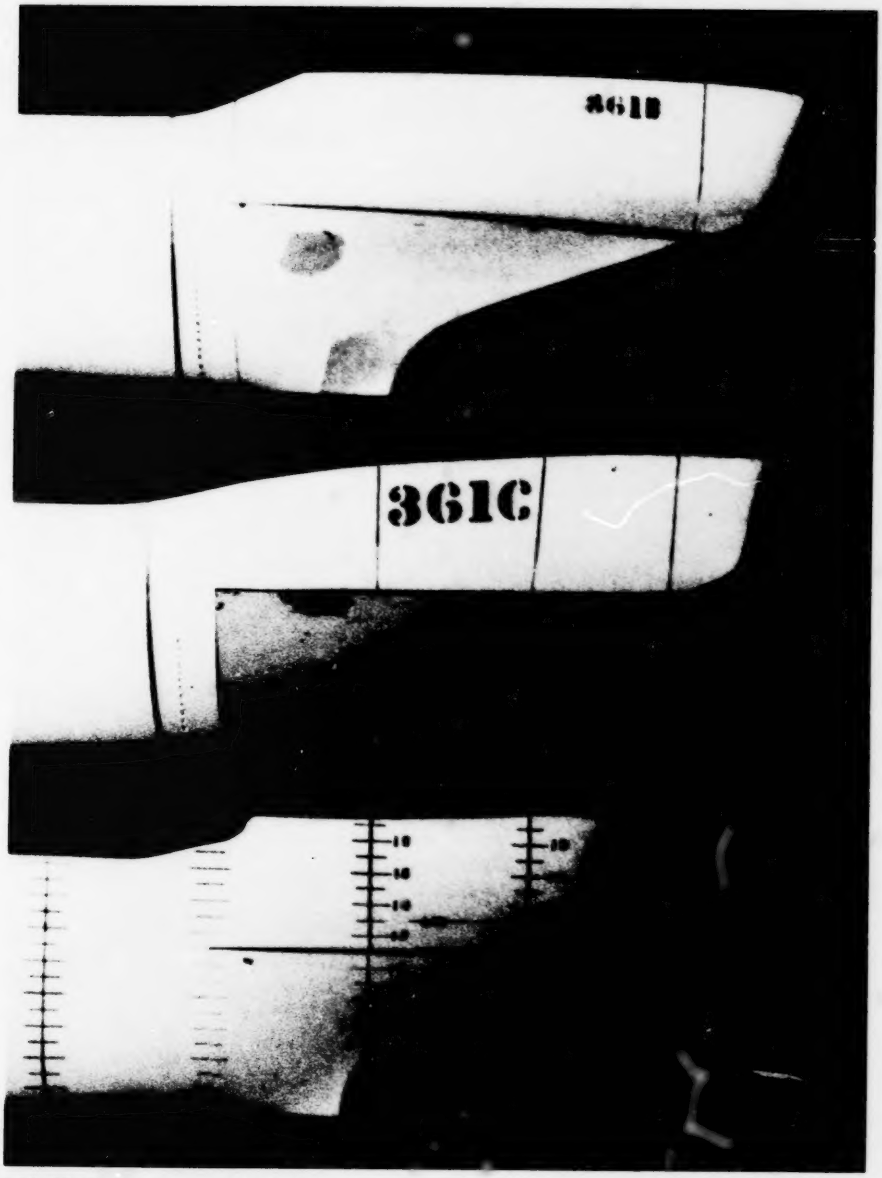
Melville Shipping Ltd., Calgary, Alberta
German and Milne Inc., Montreal, Quebec
Albery, Pullerits, Dickson & Associates Ltd., Don Mills, Ontario
Arctec Canada Ltd., Kanata, Ontario

Reports

All M.V. *Arctic* scientific program reports prepared to date have received limited government circulation pending the development of a dissemination strategy.

Schedule: March 1983 — March 1985
Funding: Transport Canada Energy Program — $540,500

Project Numbers: 4823-4-5-6-7
File Numbers: D-1460-166-33, 34, 35, 36, 37
Project Officer: Richard Bertrand



Original (bottom) and proposed M.V. Arctic bow forms

M.V. *Arctic* Bow Redesign Study

Description

This study involved redesigning the M.V. *Arctic* bow shape so as to improve the vessel's overall performance in ice and open waters.

A design criterion for the bow was that it meet the Arctic Shipping Pollution Prevention Regulations that between June 25 and November 25 of any given year, a ship can proceed at slow speed through first-year level ice up to 56 cm thick. Operating experience has shown, however, that the ice can be multi-year or glacial, as thick as two metres, and include pressure ridges.

This study was further warranted when bottom damage was discovered on the M.V. *Arctic*. This damage was probably caused by heavy ice being forced below the hull, damaging the hull when it re-emerged.

The redesign study took place in three phases. Phase I concentrated on identifying the environmental design criteria, which included analyzing ice regimes and open sea states applicable to commercial voyages by the M.V. *Arctic*. Phase I also focussed on developing alternative bow forms.

Phase II involved open water and ice tank testing of selected bow forms on a model of the M.V. *Arctic*. The National Research Council's Arctic Vessel and Marine Research Institute carried out open water and seaway tests to evaluate the resistance and propulsion characteristics of the proposed bow forms.

Phase III verified ice resistance data obtained from Canadian ice tank model tests. Similar tests were conducted in the Hamburg Ship Model Basin and the Wartsila Arctic Research Centre, using existing and modified bow forms.

Progress to July 1984

This project is nearing completion. It is expected that one of the bow configurations developed by the contractors will be fitted to the M.V. *Arctic* in the near future.

Contractors

Melville Shipping Ltd., Calgary, Alberta
National Research Council, Ottawa, Ontario

Subcontractors

Arctec Canada Ltd., Kanata, Ontario
Hamburg Ship Model Basin, Hamburg, Germany
Wartsila Arctic Research Centre, Helsinki, Finland

Reports

TP 5044E, M.V. *Arctic* and two alternative bow designs — results of resistance, propulsion and overload experiments with model hulls 326, 326B and 326C and model propeller 68, Arctic Vessel and Marine Research Institute, National Research Council, 1983.
Draft (TP 5455E), Redesign of the M.V. *Arctic* bow, design & model testing, summary report, Melville Shipping Ltd.
Draft (TP 5456E), Redesign of the M.V. *Arctic* bow, design and model testing, Melville Shipping Ltd.
Draft (TP 5812E), Redesign of the M.V. *Arctic* bow, additional model tests at HSVA and WARC, Melville Shipping Ltd.

Schedule: December 1982 — September 1984

Funding: TDC-AAMP —	$353,400
Transport Canada Energy Program —	$ 61,500
Total —	$414,900

Project Numbers: 4828, 4871, 4958, 4969
File Numbers: D-1460-166-32, 41
Project Officer: Roy S. Nishizaki

Thyssen/Waas Icebreaking Bow Technology Transfer

Description

Among a number of types of icebreaker bow configurations, recent attention has been directed to the Thyssen/Waas prototype bow demonstrated on the West German icebreaker *Max Waldeck*.

The main features of the Thyssen/Waas bow are its flat bottom and parallel side walls, which meet the bottom in a sharp edge. The width across the bow edges is greater than the beam of the vessel. Further back along the bow, the flat bottom gradually goes over to a V-shape before fairing into the mainbody.

The icebreaking mechanism of the Thyssen/Waas bow is quite different from that of traditional bow forms. The ice is broken initially by shearing along the bow sides, followed by bending fracture across the bow. The large, almost rectangular, ice floe is broken into two halves at the V-shaped part and displaced to the sides under the broken ice cover.

Potentially, this bow could reduce icebreaking costs in Canadian waters. For this reason, this study will concentrate on transferring the technological concepts of the Thyssen/Waas and determining applications to icebreaking and ice management in Canada. The transfer of the Thyssen/Waas bow technology to Canada has been arranged through a corporate agreement between Thyssen and Marystown Shipyard Limited.

Three design proposals will be developed by the contractor in this project. Following the selection of the most promising design, detailed specifications for integrating the Thyssen/Waas bow with hulls of ice-classed vessels will be developed. Economic factors also will be considered.

Progress to July 1984

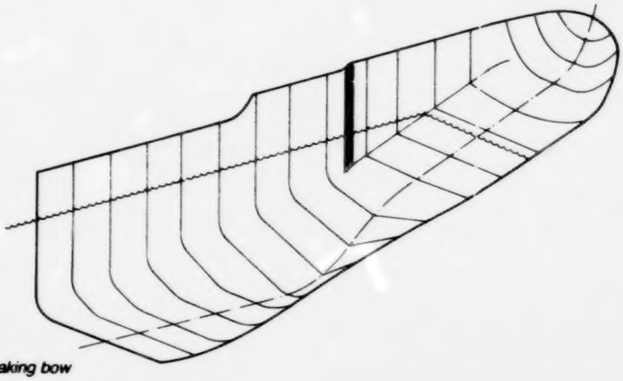
The review of Thyssen/Waas bow technology has been completed. Three vessel design proposals have been prepared and are under examination.

Contractor

Marystown Shipyard Limited, Marystown, Newfoundland

Report

None to date



Sketch of Thyssen/Waas icebreaking bow

Schedule: May 1983 — May 1985
Funding: TDC — $140,000

Project Number: 6026
File Number: D-1460-205
Project Officer: Roy S. Nish

Segmented Model Ice Tests

Description

Icebreaking involves several complex inter-related mecnanisms and processes. It has been hypothesized that several distinct elements contribute individually to ice resistance and icebreaking forces. To date, however, only the total net sum of all forces has been effectively measured in model tests. The contribution of individual components has not yet been experimentally measured.

A new technique for testing model ships in ice was developed by the contractor in the project, providing an opportunity to test components of the total force. A model of the *Pierre Radisson* was built with one side of the forebody waterline area having three independent segments of hull surface. Each segment is instrumented with sensors to monitor and define forces acting on that segment in terms of normal and frictional components of ice load. Calibration and preliminary iterative resistance testing of the model has been carried out to evaluate the system and correct minor deficiencies.

Preliminary results show that the segmented model technique can measure ice load location and magnitude. Force location data are in agreement with analytical projections, but there is some difference between projections and the actual magnitude of ice forces. A subsequent project is planned to further refine the model and the calibration techniques.

Progress to July 1984

Technical work has been completed; reports are in preparation.

Contractor

Arctec Canada Ltd., Kanata, Ontario

Reports

Draft (TP 5501E), Segmented model testing in ice: development of techniques, Arctec Canada Ltd.
Draft (TP 5500E), Segmented model testing in ice: development of techniques, summary report, Arctec Canada Ltd.

Schedule: January 1983 — December 1984
Funding: Transport Canada Energy
Program — $212,000

Project Number: 4847
File Number: D-1460-194
Project Officer: Ian M. Bayly

Antarctic Icebreaking Tests

Description

This project is a continuation of data collection on level ice resistance and hull/ice interaction forces. Data on a variety of ice conditions have been obtained from expeditions on the U.S. Coast Guard's *Polar Sea* to the Bering Strait and North Chuckchi Sea regions. Uniform level ice, however, has been difficult to find in those areas.

In this project, data was collected from thick, level, uniform ice during the *Polar Sea*'s annual resupply voyage to the Antarctic, where uniform ice ranges in thickness from one to two metres. As this vessel was used for the 1983 winter Arctic tests, it was already equipped with an extensive set of sensors. However, recording, measuring, and processing equipment was replaced.

With sensors installed on board the ship, other components readily available, and the ship's schedule taking her to an ideal location, this was a good opportunity to collect valuable data at a reasonable cost.

Progress to July 1984

The voyage has been completed. Data reduction, analysis, and reporting are in progress.

Contractors

Arctec Canada Ltd., Kanata, Ontario
Arctec Inc., Columbia, Maryland (under U.S. contract)

Report

None to date

Schedule: August 1983 — November 1984
Funding: TDC-AAMP — $161,000

Project Number: 6031
File Number: D-1460-181
Project Officer: Ian M. Bayly

Arctic Ship Task Analysis and Navigability Study

Description

An arctic marine simulator would be a valuable tool in establishing a safe and efficient year-round navigation capability in Canadian Arctic waters.

TDC and the Canadian Coast Guard (CCG) have already conducted considerable research that can be used in developing an arctic marine simulator. One focus concentrated on developing equations of the ships' motion in ice, which were needed to create realistic visual imagery for the simulator. Other work took an ergonomic approach, exploring questions of fidelity in perception of form, colour, texture, motion, etc. This research entailed the first systematic arctic navigation task analyses ever performed.

The current project combines both ergonomic and oceanographic data approaches. Task analyses of crew activities on the bridges of three different supply ships will be conducted simultaneously with ice navigability observations. Besides facilitating the development of the simulator, the data collected during the voyages will add to the understanding of human limitations with respect to such technologies as remote sensing, communication, and night lighting.

Training and research scenarios for use with an arctic simulator, based on critical navigation incidents that occur aboard these vessels, will also be developed. Finally, additional data for a model to measure the effectiveness of simulator training regimes, as well as effects of changes in bridge design due to new technologies, will be obtained.

Progress to July 1984

Preparations are being made aboard the Swedish ship, *Thuleland*, and Dome ships, *Kigoriak* and *Robert Lemeur*, for the task analyses and data collection during their scheduled fall 1984 voyages.

Contractor

MMS Man-Machine Systems Consultants Inc., Toronto, Ontario

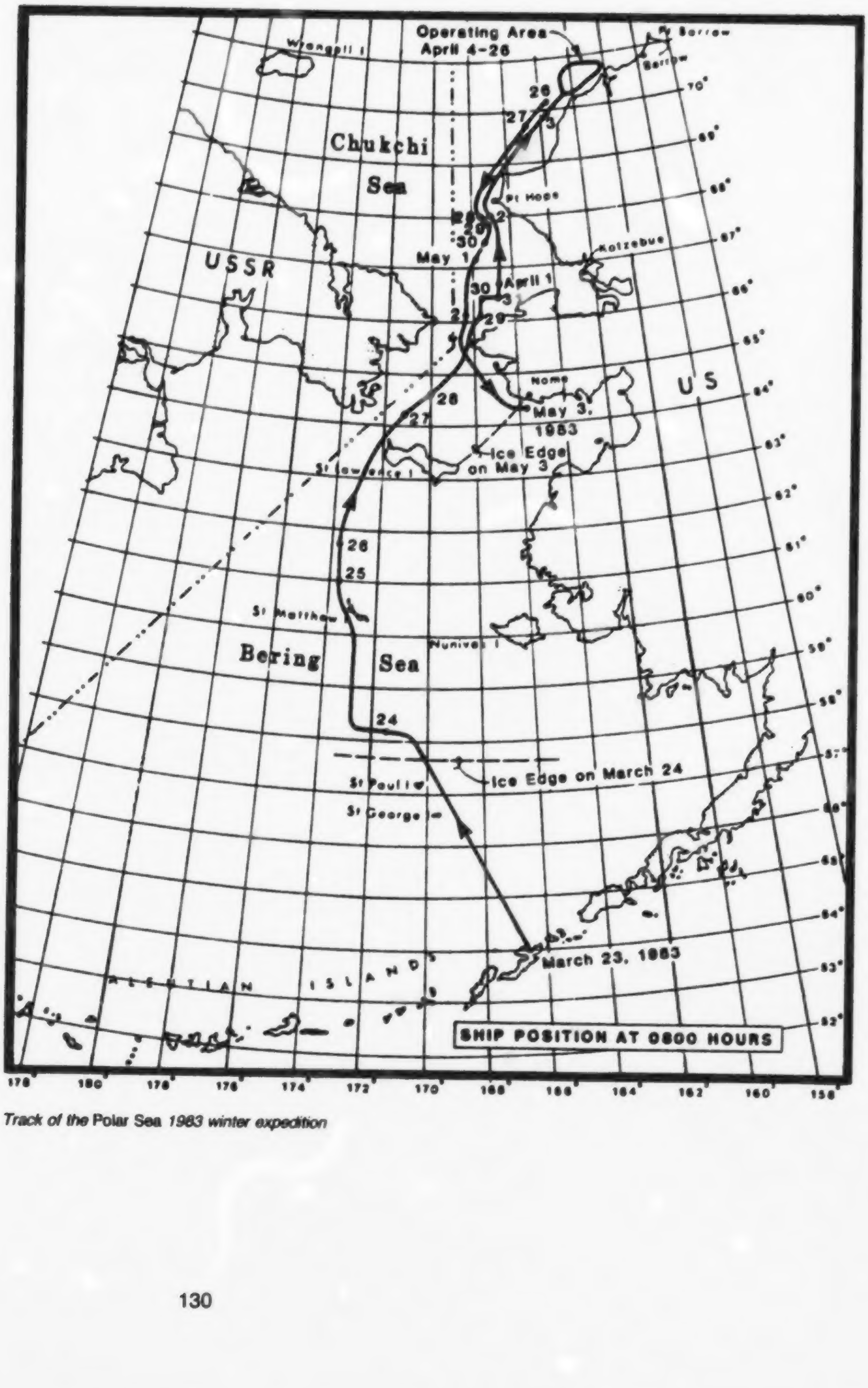
Report

None to date

Schedule: July 1984 — February 1985

Funding: TDC —	$ 50,000
DSS —	$ 73,400
CCG —	$ 50,000
Total —	$173,400

Project Numbers: 6324-5-6
File Number: D-1460-145-11-2
Project Officer: Dr. Ruth M. Heron


Operating Area
April 4-26
Pt Barrow
Barrow
Wrangell I
Chukchi Sea
USSR
Pt Hope
Kotzebue
May 1
April 1
Nome
U S
May 3, 1983
Ice Edge on May 3
St Lawrence I
St Matthew
Nunivak I
Bering Sea
Ice Edge on March 24
St Paul I
St George I
March 23, 1983
ALEUTIAN ISLANDS
SHIP POSITION AT 0800 HOURS
70°
69°
68°
67°
66°
65°
64°
63°
62°
61°
60°
59°
58°
57°
56°
55°
54°
53°
52°
178
180
178
176
174
172
170
168
166
164
162
160
158

Track of the Polar Sea *1983 winter expedition*

Hull Ice Loads, USCGC *Polar Sea* 1983 Arctic Voyage

Description

Since the late '70s, U.S. Coast Guard icebreaking vessels *Polar Sea* and *Polar Star* have been used in a series of data gathering expeditions in arctic waters. The program, sponsored by the U.S. Maritime Administration and supported by oil companies, is aimed at increasing marine access to arctic resources without endangering human life or the environment. TDC's participation in this program began in 1981.

The present project, to measure and analyze ice pressures on the hull of the *Polar Sea*, was carried out by both Canadian and U.S. contractors with the support of the U.S. Ship Structure Committee.

Finite element modelling studies of a 12 m^2 hull panel were conducted during the system design phase of this project. Subsequently an extensive instrumentation system was installed aboard the ship to measure ice forces on 80 individual sub-panels within the test panel. Including early spring 1983, the *Polar Sea* has successfully made three ice force testing expeditions. Speed, power, acceleration, and other ship performance and response parameters were also measured in support of this hull load project and other studies.

The data collected during these probes have been reduced and analyzed. The results, which will help establish local ice load criteria for arctic class ships, will be published for the use of designers and operators of marine transportation systems and other offshore structures.

A fourth expedition is scheduled for fall 1984.

Progress to July 1984

This project is nearing completion.

Contractors

Arctec Inc., Columbia, Maryland (under U.S. contract)
Arctec Canada Ltd., Kanata, Ontario

Report

Draft, Ice loads and ship responses to ice, Arctec Inc. and Arctec Canada Ltd.

Schedule: January 1983 — December 1984
Funding: TDC — $273,000 (Canadian share)

Project Number: 4577
File Number: D-1460-181
Project Officer: Ian M. Bayly

Propeller/Ice Finite Element Model: Phase II

Description

Propeller damage as a result of interaction with ice in arctic waters can bring a ship to a standstill. For this reason, it is vitally important to marine traffic to achieve propeller reliability. In line with this goal, this project is part of a program directed towards minimizing damage to propellers due to ice.

An earlier project in this program applied finite element modelling to study stress distribution in propeller blades of various dimensions which were assumed to have been subjected to simple uniform pressure loading. One conclusion was that a more complex loading system is required to accurately model the effects of parametric variations in propeller dimensions.

To facilitate the continued study of propeller/ice interaction, this project is developing two and three-dimensional finite element models to assess the stress and fracture patterns in a block of ice penetrated by a propeller blade. These models should provide reliable definition of the magnitude and distribution of forces interacting between blade and ice.

Progress to July 1984

Preliminary work on the development of the blade finite element model and a simplified form of interaction model has been completed. A finite element modelling program has been selected for the study of ice characteristics, and work is in progress on the two-dimensional interaction.

Contractor

Martec Ltd., Halifax, Nova Scotia

Report

None to date

Schedule: March 1983 — September 1985

Funding: TDC —	$ 63,500
TDC-AAMP —	$ 68,000
Transport Canada Energy Program —	$123,000
Total —	$254,500

Project Numbers: 6003, 6004, 6005
File Number: D-1460-156-3
Project Officer: Ian M. Bayly

Ice Nozzle Strength

Description

Propeller nozzles on ice-going vessels provide an important safety element because they protect the propeller. However, nozzles themselves are subject to extreme ice loads, and although they normally protect the propeller, damage to a nozzle would probably immobilize the propeller.

With this in mind, this project is studying factors that affect strength and design criteria of propeller nozzles on ice-going ships. Among the factors being defined are:

- ship size and power;
- nozzle geometrics, locations, and attachments; and
- ice features.

The researchers are developing analytic and finite element models to determine the stresses and deformations in different size nozzles under potentially critical arctic loading scenarios. A simplified mathematical model will also be developed. Based on the analysis of these models, they will formulate a tentative ice-going nozzle design and recommend appropriate regulatory requirements.

Progress to July 1984

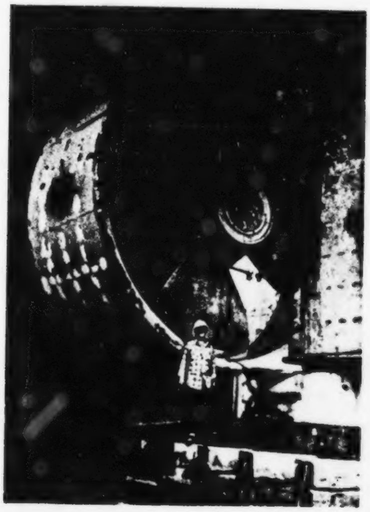
The analysis of the response of a ring to a variety of applied forces is underway. The effect of dimensional variation on the structural properties of nozzles is also being analyzed.

Contractor

Canadian Marine Drilling Ltd., Calgary, Alberta

Report

None to date

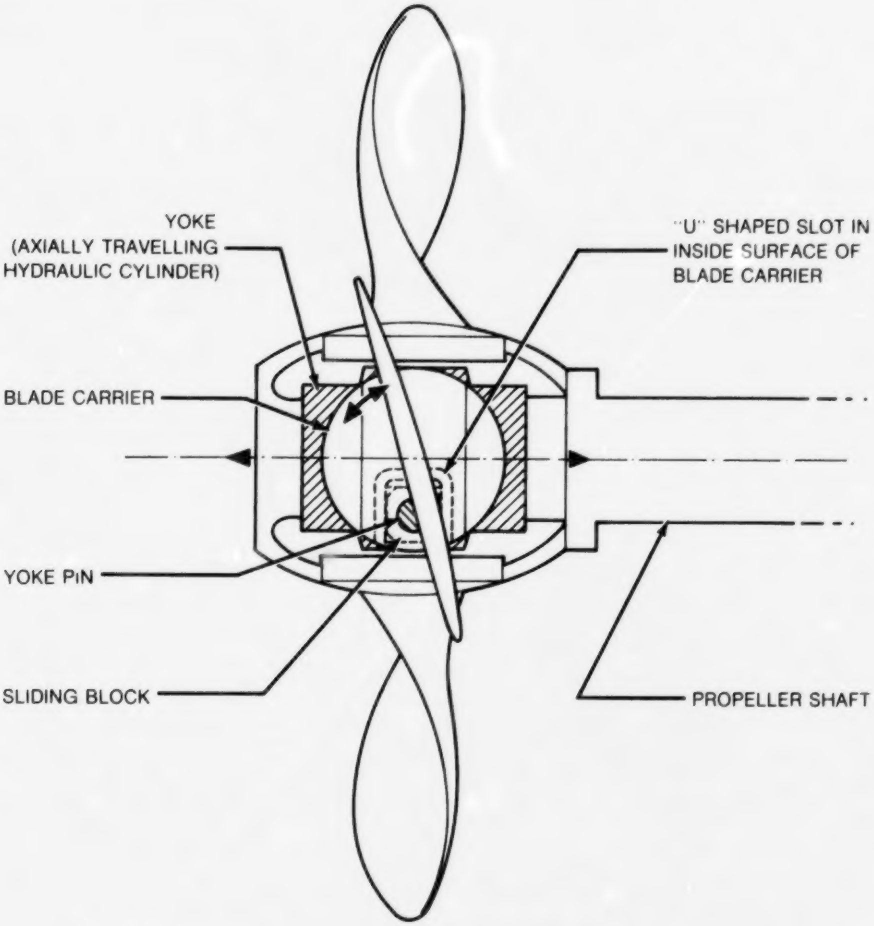


This propeller nozzle, measuring 5.3 metres in diameter, protects the single screw from ice damage and increases the vessel's bollard pull by 30 percent

---

Schedule: March 1984 — March 1985
Funding: Transport Canada Energy Program — $130,000

Project Number: 6080
File Number: D-1460-156-5
Project Officer: Ian M. Bayly


YOKE
(AXIALLY TRAVELLING
HYDRAULIC CYLINDER)
"U" SHAPED SLOT IN
INSIDE SURFACE OF
BLADE CARRIER
BLADE CARRIER
YOKE PIN
SLIDING BLOCK
PROPELLER SHAFT

Drawing of propeller hub mechanism used to measure propeller interaction parameters

Ice Forces on Nozzle Propellers

Description

During icebreaking operations, pieces of ice frequently hit propeller blades, even when the propeller has a protective nozzle. As full-scale measured ice impact data are not available, the objective of this project is to obtain information on how the controllable pitch propeller blade, hub mechanism, and propeller shaft are affected by these ice interaction forces.

This work follows a project conducted in 1983 in which a propeller blade of the icebreaking supply vessel, *Robert Lemeur*, was instrumented to measure these forces. The data collected during that test period were limited, but sufficient information was obtained to warrant the continuation of testing with more extensive instrumentation. Winter docking of the *Robert Lemeur* provided the opportunity to refurbish the instrumentation on the blade and to add sensors to the propeller hub mechanism and stern bearing.

The measurement of magnitude and location of ice/blade interaction forces and the resultant effect on the other instrumented components took place during a week-long test period. At the same time, researchers also collected ice condition data, which will be correlated with other recorded measurements. The analysis of this information in engineering terms will provide the basis upon which improved design and regulations of propellers, shafting, and related items can be developed.

Progress to July 1984

A preliminary analysis of the extensive data with near real-time reduction to engineering quantities has been done. Statistical measurements will continue to be collected during the operating season from a few sensors. Subsequently, a full analysis of results will be performed.

Contractor

Canadian Marine Drilling Ltd., Calgary, Alberta

Report

None to date

Schedule: February 1984 — May 1985

Funding: TDC —	$ 43,100
TDC-AAMP —	$150,000
Transport Canada Energy Program —	$400,000
Total —	$593,100

Project Numbers: 6176, 6177, 6178
File Number: D-1460-156-6
Project Officer: Ian M. Bayly

Protection of Propellers in Ice

Description

Reduction in the risk of propeller damage can substantially improve the safety and reliability of ships operating in heavy ice regions.

Effective protection systems designed to avoid propeller contact with ice would permit the use of substantially lighter and more efficient propellers, as well as reducing vulnerability to damage.

Since screening systems for propellers are prone to clogging with broken ice, this TDC project has centred on the investigation of inflow velocities, ice shedding characteristics, and the design of propellers that would function efficiently in the flow conditions induced by various screening configurations.

Early phases of the project concentrated on the assessment of various conceptual designs. Following this, a system was selected for a model study of the 150,000 horsepower icebreaker Polar VIIA hull. Initial test results indicate potential for significant increase in propeller efficiency.

Progress to July 1984

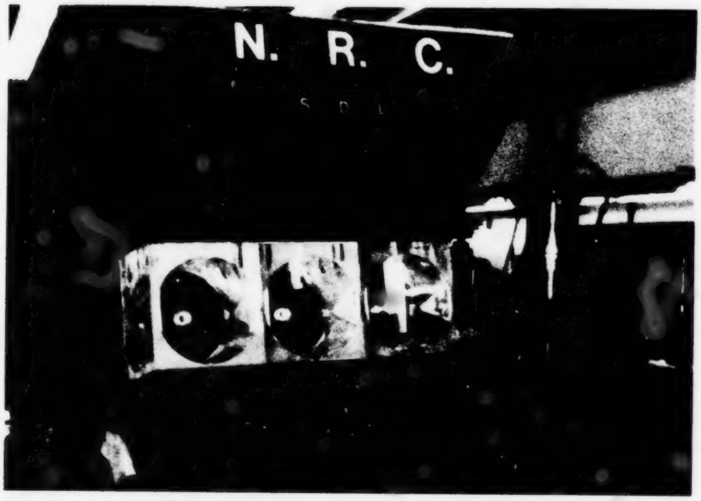
Streamlining of the protection system and modifications to the after section of the model hull to reduce drag have been completed. Continuation of testing of the model is scheduled for October 1984.

Contractor

Davis Engineering Ltd., Ottawa, Ontario

Report

None to date



Streamlined propeller protection system on hull model

Schedule: February 1983 — January 1985
Funding: Transport Canada Energy
Program — $84,000

Project Number: 4949
File Number: D-1460-137-2
Project Officer: N.R. Gore

Ultrasonic Doppler Velocimeter for Icebreakers

Description

Icebreaking operations would be quicker, more efficient, and more economical if the precise speed of the ship, and its relationship to the ice surface, were known. This information is not provided by current shipboard equipment. Advances have been made in Doppler radar technology, but there are no commercial velocimeters capable of accurately measuring speeds under 1 km/h. Another drawback is that this radar operates in the gigahertz frequency range and is sensitive to parasitic reflections from level or wet surfaces, making it unsuitable for icebreakers, which require precise readings at extremely low speeds. Therefore, an investigation of an ultrasonic device was pursued in order to overcome these problems.

Reseachers designed and constructed a laboratory model of an ultrasonic Doppler velocimeter, which operated in the lower ambient noise frequency band to minimize the effect of the noisy environment aboard an operational icebreaker. The model was tested in the laboratory.

Satisfactory results from the tests were followed by the construction of a prototype.

Progress to July 1984

Limited tests of the prototype, conducted during the 1983/84 ice season, uncovered problems with the ultrasonic transducer. A search is underway for a new transducer supplier.

Contractor

Gentec Inc., Ste. Foy, Quebec

Report

None to date

Schedule: February 1983 — June 1985
Funding: Transport Canada Energy

Program —	$240,400
DSS —	$ 68,640
Total —	$309,040

Project Numbers: 4774, 4779
File Number: D-1460-188
Project Officer: Roy S. Nishizaki

Hull Corrosion and Coatings

Description

Corrosion of hull structures, particularly of welded seams in areas vulnerable to ice scouring, is a severe maintenance problem. Protective coatings are used to combat corrosion, but high-performance varieties are expensive, and their reliability is often diminished by the difficulties of applying them in the Canadian climate.

In this project, researchers have been investigating heavy duty coatings under the kinds of abuse frequently encountered by ice-going vessels. Special attention has been given to factors that affect coating performance, such as:

- surface preparation requirements;
- application techniques under adverse weather conditions; and
- resistance of coatings to impact and underfilm corrosion.

Two related areas also being considered in this study are welding materials and procedures and their effect on corrosion resistance, and the feasibility of operating a cathodic protection system under ice scouring conditions.

Data collection methodology has involved an extensive literature survey and visits to Canadian and international shipyards to gather firsthand information from marine authorities and operators.

Progress to July 1984

Paint failure and hull weld corrosion problems have been documented. Investigations are continuing in all areas.

Contractor

B.H. Levelton & Associates Ltd., Vancouver, British Columbia

Report

None to date

Schedule: December 1982 — December 1984
Funding: TDC — $65,000

Project Number: 4239
File Number: D-1460-145-7
Project Officer: Ian M. Bayly

Icebreaking Resistance of SWATH Ships

Description

The waves formed by a ship's hull, and their interference with the ship's progress, could be significantly reduced if the hull ran below the water surface. Various concepts of cargo ships with such hulls have been developed, ranging from a submarine to a semi-submersible, a craft whose hull is mostly submerged. For better stability, twin-hull versions of the semi-submersible have been designed, with a flat deck uniting the two hulls. These are known as small waterplane area twin hull (SWATH) ships.

In an earlier theoretical investigation, the contractor had predicted a sizeable reduction in icebreaking resistance of the thin hull struts as compared to a conventional hull. In this project, researchers have been collecting icebreaking resistance data for SWATH ships. They conducted hydrostatic and hydrodynamic analyses of the SWATH ship concept. Based on the data, researchers constructed two scale models which represent a polar LNG tanker of 140,000 m³ capacity and a patrol ship able to move through ice up to one metre thick. To validate the prediction of ice resistance of the SWATH ship concept, the models were tested in an ice basin at the National Research Council.

Progress to July 1984

Analysis of the test data is nearing completion.

Contractor

German and Milne Inc., Montreal, Quebec

Report

None to date

Schedule: March 1983 — December 1984
Funding: Transport Canada Energy

Program —	$ 78,700
DSS —	$ 70,000
Total —	$148,700

Project Numbers: 4915-6
File Number: D-1460-157-2
Project Officer: Jacques E. Laframboise

Ice Loads on Fishing Vessels

Description

Declining fish stocks and fishing quotas in conventional open water fishing areas mean extended fishing off the Labrador coast in areas and seasons where floating ice is a major hazard.

Although conventional fishing vessels are already built to the highest standards specified for ice strengthening, many have sustained hull damage from floating ice pieces. To facilitate access to northern fish stocks, improved hull structure design and regulatory criteria must be developed for vessels operating in ice off Labrador. Contributing to this overall objective, the contractor is undertaking the following tasks:

- reviewing and documenting recent ice damage to fishing vessels; and
- designing and installing an instrumentation system on a fishing vessel, to measure strains and to deduce magnitude and location of interaction forces occurring during operations in floating ice.

Progress to July 1984

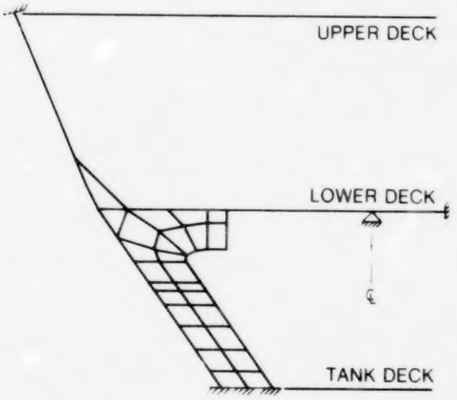
An instrumentation system to measure ice loads was developed, installed, and calibrated on the fishing vessel *Cape Briar*. Although the system was deployed only once during the 1983/84 season, a number of good readings were obtained. Analysis of the data is in progress. Consideration is being given to similar efforts next winter.

Contractors

Fisheries Resource Development Ltd., Halifax, Nova Scotia
Arctec Canada Ltd., Kanata, Ontario

Report

None to date



Finite element analysis of instrumented hull structure

Schedule: September 1983 — December 1984

Funding:	
TDC —	$ 15,000
TDC-AAMP —	$ 35,000
CMTA —	$ 20,000
DSS —	$110,000
DFO —	$ 25,000
Total —	$205,000

Project Numbers: 6092, 6093, 6094, 6095, 6096
File Number: D-1460-210
Project Officer: Ian M. Bayly

Air Cushion Technology Research

Description

The University of Toronto's Institute for Aerospace Studies (UTIAS) was established in 1970 to support Canadian industry and government in the development of air cushion technology. TDC has supported the Institute financially for the last seven years in the following areas of research:

- Investigation of the dynamic behaviour of air cushion skirt systems. Tests of the scale models of a skirt system provided by Hoverlift Systems Ltd. were conducted on the UTIAS circular track, among others. Researchers defined the operational limits of this system and compared it with multicellular cushion systems.
- Investigation of dynamic instabilities and damping in air cushion systems, including the pneumatic circuit of the air cushion and the effect of certain components on overall stability.

Experiments completed in 1983 showed that the viscoelastic properties of materials used to make air cushion skirts have a major effect on the dynamics. They also showed that skirt deflections induced by cushion pressure variations have a significant effect on the pneumatic capacity of the cushion and the effective hovergap, although these deflections are small.

Current work includes the investigation of damping mechanisms, passive and active, which can forestall the pneumatic heave instability in large air cushion vehicles of the type proposed for use as icebreakers in the Arctic.

Progress to July 1984

Technical work is nearing completion.

Contractor

University of Toronto, Institute for Aerospace Studies, Toronto, Ontario

Report

Draft, Research on air cushion stability, University of Toronto, Institute for Aerospace Studies.

Schedule: January 1982 — December 1984
Funding: TDC — $250,000

Project Number: 4481
File Number: D-1460-125-2
Project Officer: Jacques E. Laframboise

Advanced ACIB Concepts Design Study

Description

Air cushion icebreaking bow (ACIB) technology has contributed greatly towards significant improvements in icebreaking performance. In specific tests, icebreakers with the attached air cushion bow obtained a drag reduction of 90% over that of conventional icebreakers.

This first-generation ACIB has operated successfully for three seasons in the experimental mode. However, in order to make the system truly effective, attention must be given to identifying potential users and developing cost-effective designs to meet their needs.

In this project, potential users in two operating environments, inland and mid-Arctic waters, were interviewed to determine their requirements. Based on this information, the contractor prepared preliminary performance specifications for two classes of ACIB. The two conceptual ACIB designs subsequently developed were:

- a circular craft for inland waters weighing 275 tonnes and powered by two main diesel engines; and
- a rigid sidewall mid-Arctic ACIB weighing 1200 tonnes and powered by four diesel engines.

Progress to July 1984

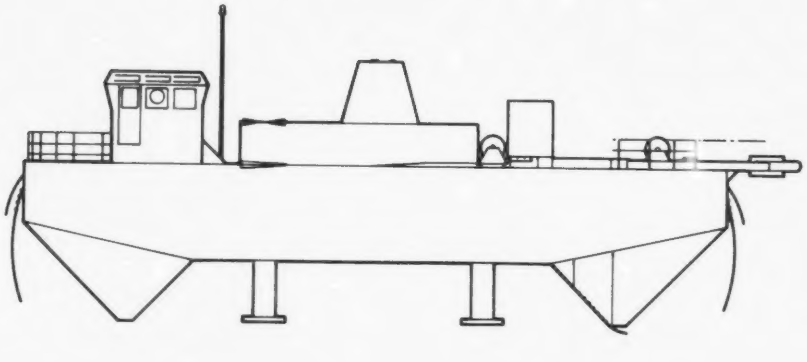
This project has been completed.

Contractor

German and Milne Inc., Montreal, Quebec

Reports

Draft (TP 5653E), Advanced ACIB concepts design study, German and Milne Inc.
Draft (TP 6014E), Advanced ACIB concepts design study, summary report, German and Milne Inc.



Schematic of side elevation of ACIB for inland waterways

Schedule: January 1984 — July 1984
Funding: Transport Canada Energy Program — $118,000

Project Number: 6081
File Number: D-1460-163-14-9
Project Officer: Jacques E. Laframboise

Air Cushion Icebreaking Bow Evaluation Program

Description

TDC has contributed significantly to the development and testing of air cushion icebreaking bow (ACIB) technology for the past several years.

In 1979, the Canadian Coast Guard (CCG) sponsored the construction of an ACIB that featured a flexible notch structure designed to fit closely to the bow of certain CCG ships. The first limited tests of the ACIB were carried out in Thunder Bay, late in the 1981/82 season. Although little icebreaking work was done, deficiencies in the design were determined and corrective measures taken. The 1982/83 icebreaking season, although unseasonably mild, allowed TDC to verify the operational envelope of the craft.

This project covers the 1983/84 testing of the ACIB under more seasonal winter conditions. The craft was evaluated during icebreaking and track clearing operations with the CCG *Alexander Henry*. During normal ice management operations, the ACIB/*Henry* combination broke ice covers of 35 cm to 60 cm, over 250 nautical miles. In a special ice-clearing operation at the Manitoba Wheat Pool slip in the port of Thunder Bay, ice up to 90 cm thick was successfully cleared with no undesirable loads on the dock structure.

Results of the testing program have shown that the mean icebreaking speed of the ACIB/*Henry* combination is ten times greater than that of the *Henry* operating alone. The assembly was easily manoeuvred, and very tight turns were possible. Reduced fuel consumption and improved track clearing time were noted. Ramming operations have been almost eliminated, considerably reducing the wear and damage of the hull and propulsion system. Furthermore, less strain was put on the drive train due to the considerable reduction of reversing operations.

Advancements in ACIB technology have improved the overall effectiveness of icebreaking operations in coastal and inland waters. This technology will now be extended for arctic applications.

Progress to July 1984

This project has been completed.

Contractor

German and Milne Inc., Montreal, Quebec

Reports

TP 4446E, Air cushion icebreaking bow (ACIB) trials report: 1982/83, German and Milne Inc., 1983.
TP 5497E, Air cushion icebreaking bow (ACIB) operation report, 1983/84, German and Milne Inc., 1984.

Schedule: December 1983 — June 1984
Funding: Transport Canada Energy Program — $114,000
Project Number: 6110
File Number: D-1460-163-14-10
Project Officer: Jacques E. Laframboise

Ice Information System Development

Description

The level of commercial activity in the Arctic region is accelerating owing to quantities of natural resources available in the area. Despite ice-infested waters, marine transportation remains the logical means of moving northern resources to world markets. For this reason, there is a need for further information about all aspects of ice navigation.

Data gathering systems such as side loading aperture radar (SLAR) and synthetic aperture radar (SAR) need to interface with an information processing system in order to be usable.

Remote sensing communications, data processing, and navigation system (REMSCAN) is a concept that can interface with various data collection systems, and select and display information in a form readily usable by an operator.

The contractor identified the needs of all potential users and examined available and soon-to-be-available technology applicable to REMSCAN.

Information packages were defined and the operational requirements detailed for a system to provide such packages. A software model was developed for an optimum route through Arctic waters.

Progress to July 1984

Technical work has been completed, a report is in preparation.

Contractor

Canadian Marine Drilling Ltd., Calgary, Alberta

Report

None to date

Schedule: March 1982 — September 1984

Funding: TDC —	$180,000
Dome Petroleum Ltd. —	$ 45,000
Total —	$225,000

Project Number: 4954
File Number: D-1460-197
Project Officer: Maurice Audette

Shipboard Multi-Task Ice Data Analysis System

Description

The field of remote ice sensing has advanced rapidly in recent years, providing marine operators with reliable information on ice conditions and hazards. Available from such sources as satellites, airborne and conventional marine radar, this information has greatly increased the safety and reliability of arctic marine operations. But it has also created problems for its users, who must deal with the large amount and the different nature of the data generated bv these various sources. The proposed solution is the multi-task ice data analysis system (MIDAS), an integrated facility capable of receiving and using the different data sources to provide realistic ice imagery for route planning and navigation support.

The goal of this TDC-sponsored study is to develop a design for a shipboard MIDAS that would enable marine operators to select routes avoiding frequent and heavy ice conditions and to note ice hazards in the ship's vicinity, thus reducing operating costs, ship damage, and travel time.

To accomplish the design of a shipboard MIDAS, the contractor is addressing the following tasks:

- identifying optimum real-time imagery equipment;
- demonstrating the usefulness of high-resolution radar imagery for arctic marine operations;
- collecting a data set of airborne radar imagery with marine radar imagery for application to an integrated display and analysis system;
- determining user requirements for MIDAS;
- examining market potential; and,
- preparing functional specifications.

Progress to July 1985

Radar data receivers and other data collection and processing equipment were installed aboard the M.V. *Arctic*, and ice imagery was successfully received and recorded during fall and spring voyages to Baffin Bay and Lancaster Sound. Analysis of these field operations will yield the user requirements and functional specifications for MIDAS.

Contractor

INTERA Technologies Ltd., Calgary, Alberta

Report

None to date

Schedule: October 1983 — December 1984

Funding: TDC —	$489,100
Intera and others —	$420,000
Total —	$909,100

Project Number: 6086
File Number: D-1460-209
Project Officer: Maurice Audette

Remote Sea Ice Thickness Sensor Development

Description

The development of an all-weather airborne instrument to measure the thickness of sea ice would facilitate navigation, extend the shipping season, and improve ship safety. Such a sensor would be a valuable asset to the Canadian Coast Guard on its icebreaker helicopters and Electra ice patrol aircraft.

Researchers had determined previously that the most suitable concept for an airborne remote measuring sensor was a combined synthetic pulse/impulse radar. Their experimental radar equipment was tested in the Beaufort Sea in April 1980. The results verified that radar signals can penetrate thick and thin sea ice to an adequate depth, and that one antenna can be used for both synthetic pulse and amplitude-modulated radar signals.

An operational prototype was developed for field testing. The receiver was refined to permit digital readouts of ice thickness measurements, and a new, fixed antenna was designed for mounting between the struts of a helicopter.

The antenna and the sensor were installed on a helicopter and preliminary field trials were conducted on Lake Melville, Newfoundland, to validate measurement techniques and refine hardware.

Progress to July 1984

TDC is awaiting documentation on the prototype equipment before proceeding with trials in the Arctic.

Contractor

MPB Technologies Inc., Montreal, Quebec

Reports (from earlier research)

TP 2634E and TP 2635E, Development of a remote sea ice thickness sensor, MPB Technologies Inc., 1980.

TP 3341E, Radio frequency circuit design for automatic data processing of radar signals of remote sea ice thickness sensor, MPB Technologies Inc., 1981.

Schedule: August 1978 — September 1984

Funding:	
TDC-AAMP —	$163,600
Transport Canada Energy Program —	$237,500
Total —	$401,100

Project Numbers: 4910, 4232
File Number: D-1460-126-6
Project Officer: Maurice Audette

Portable Ice Thickness Sensor

Description

The development of a prototype ice thickness sensor is nearing completion, and the results of laboratory testing to date have been very encouraging. This sensor offers a simple solution to the present laborious process of measuring ice thickness. It uses a new technique that involves being able to excite an ice sheet over an acoustic band with a pure tone and derive acoustic resonance peaks and phase cancellation nulls with accuracy and predictability.

This project involves the operational testing of the prototype sensor under arctic conditions. These tests should validate the accuracy and predictability of using the acoustic resonance technique as a method of measuring the thickness of floating ice sheets.

Following operational testing of the prototype, a portable system will be developed. The possibility of using a microprocessor to make this system as operator-independent as possible will also be explored.

Progress to July 1984

The arctic field tests have confirmed the viability of the acoustic resonance ice thickness sensor. Some modifications to the prototype design have been recommended, to be followed by retesting in the Arctic.

Contractor

Polar Tech Ltd., Sidney, British Columbia

Report

None to date

Schedule: October 1983 — August 1984
Funding: TDC — $100,000

Project Number: 6098
File Number: D-1460-126-7
Project Officer: Maurice Audette

Ice Failure Model

Description

An effective ice failure model can reduce the amount of energy required to transit ice-covered water by providing a means of evaluating ice forces under various conditions. In order to do this, a number of ice-related difficulties need to be properly analyzed. For example, in actual floating ice covers, the lower surface is usually at the freezing temperature and the upper surface is subjected to air temperatures. The fact that the material parameters vary across the thickness of an ice plate has a profound effect on the stresses in the plate and therefore must be considered when developing a failure model.

This project is developing ice failure criteria based on the following considerations:

- rheological properties of ice;
- loading conditions, including vertical, horizontal, concentrated, or distributed, and covering all modes imposed by icebreaking ships; and
- ice failure modes — crushing, shearing, bending, and buckling.

In particular, the new model will take into account such elements as likely temperatures and strain rate distributions across the ice thickness; the upper and lower bounds for the flexural rigidity of ice covers; and, the maximum and minimum loads that may be required to break an actual ice cover under a variety of load distributions.

It is believed that taking these facts into consideration will lead to developing ice failure criteria that will further determine the resistance of ice to breaking.

Progress to July 1984

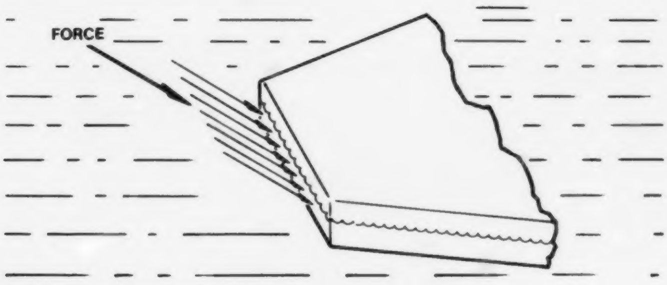
A detailed review of varying through-thickness ice properties has been carried out. Their effect on the bearing capacity of an ice sheet, the behaviour of an ice sheet under oblique forces, and the buckling and crushing failure mechanism, have been examined.

Contractor

Donald Carter, Consulting Engineer, Ste. Foy, Quebec

Report

None to date



Drawing of floating ice wedge subjected to oblique force

Schedule: October 1983 — December 1984
Funding: Transport Canada Energy
Program — $62,000

Project Number: 4770
File Number: D-1460-187
Project Officer: Ian M. Bayly

Mechanical Icebreaking and Removal Techniques

Description

TDC recognizes the need to develop innovative ice management methods to remove ice from ports and harbours without icebreaker assistance. This project investigated the feasibility of one method - the ice-block-under-ice concept, which involves the cutting of the ice cover into blocks using the combination of a "Ditch Witch" trencher and a chainsaw. Once cut, the blocks are tilted and towed beneath the surface ice, exposing an area of open water.

The contractor conducted small and large-scale tests to evaluate the effectiveness of this technique for use with landfast ice. Three small-scale tests performed on successively thicker ice demonstrated that mechanically displacing ice blocks under surrounding ice could successfully create small areas of open water. Large-scale tests were then conducted at Big Nellie Lake, Ontario, to determine whether, by cutting and towing ice blocks, large areas of open water in which ships can manoeuver could also be exposed. A secondary objective of the large-scale tests was to debug the various operational aspects of the removal technique.

The full-scale operation showed that the ice-block-under-ice concept is a feasible technique for clearing ice from harbours when icebreaker assistance is not practical.

Progress to July 1984

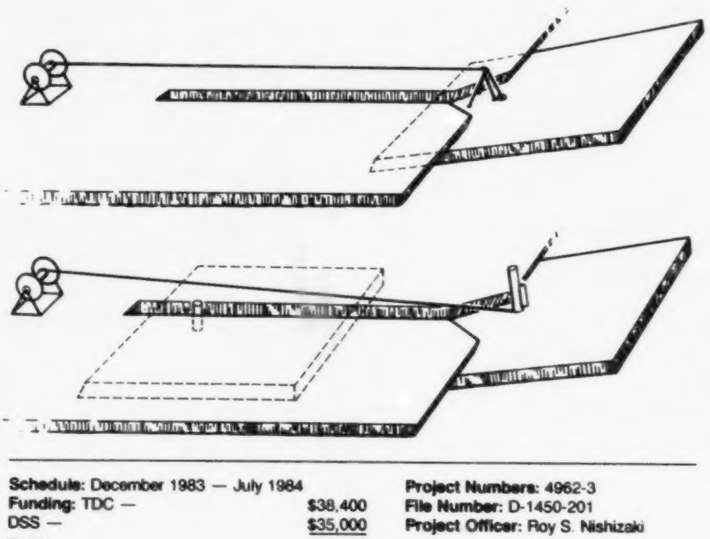
This project has been completed.

Contractor

Martec Ltd., Halifax, Nova Scotia

Report

TP 5611E, Feasibility study of mechanical ice break and removal techniques, Martec Ltd., 1984.



Ice-block-under-ice concept for clearing ice from harbours

Schedule: December 1983 — July 1984

Funding: TDC — $38,400

DSS — $35,000

Total — $73,400

Project Numbers: 4962-3

File Number: D-1450-201

Project Officer: Roy S. Nishizaki

Demonstration of Harbour Ice Management Techniques

Description

During the winter shipping season, ice barriers inhibit access to port loading berths. One method of controlling the formation of ice in loading berths is to circulate warmer water from the bottom of the berth to the surface by using an air bubbler or an air cannon mixer.

An air bubbler system incorporates a submerged, perforated pipe through which compressed air is blown. The rising air bubbles cause the water about the pipe to circulate, bringing slightly warmer water to the surface from below to melt the ice. An air cannon mixer incorporates a vertical pipe that accumulates air, then releases it periodically, through a duct, as a large bubble that acts as a piston to push the warm water to the surface.

TDC sponsored the installation and operation of both systems in Thunder Bay harbour loading berths. Ice thickness in the test and adjacent berths was monitored throughout the 1979/80 and 1980/81 operating seasons. A low-cost air blower was tested in place of the compressor, but this substitution proved to be impractical for use with the air bubbler, although it worked well with the air cannon mixer. Experiments showed that while the air bubbler could control ice formation, it was prone to damage from berthing ships. The air cannon was also successful, but each cannon was limited in its effects.

A redesigned, more robust air bubbler system was installed in a slip at Thunder Bay featuring a rake-like diffuser that blows warm air into the water. The diffuser is designed to move with the melting ice. It can be removed at the start of the shipping season, eliminating the possibility of damage from dragging anchors, propeller wash, or other causes.

In testing the air cannon system, a major advantage was determined: the direction of the horizontal flow can be controlled by a deflector, and the rate of flow by the bubble size or bubble tube length. This system can be designed to fit into the dock wall structure and away from any ice or propeller action.

When comparing the two systems in terms of overall ice melting, the air cannon system melted ice more than twice as fast as a rake diffuser bubbler system. The air cannon also melted the ice cover at a more constant rate than did the rake diffuser system. The air cannon consumes less power because a low pressure blower is used for the air supply. As well, it requires less frequent maintenance than the rake diffuser bubbler system.

Tests were also conducted using the CCGS *Alexander Henry*, with and without an air cushion icebreaking bow, to clear ice from an elevator slip. The slip was instrumented to measure ice loads due to icebreaking forces. It was concluded that the air cushion icebreaking bow can be used in a slip, whereas conventional icebreaking can result in excessive forces.

Progress to July 1984

Technical work has been completed; reports are in preparation.

Contractors

Lakehead Harbour Commission, Thunder Bay, Ontario
Arctec Canada Ltd., Kanata, Ontario

Subcontractor

V.B. Cook Co. Ltd., Thunder Bay, Ontario

Reports

Draft (TP 5831E), Air bubbler ice control experiment in Thunder Bay, Ontario, winter 1984, V.B. Cook Co. Ltd.
Draft (TP 5832E), Laboratory ice suppression experiments using a cannon bubbler, Arctec Canada Ltd.
Draft (TP 5833E), Ice management in Thunder Bay Harbour, winter 1984, summary report, Arctec Canada Ltd.
Draft (TP 5834E), Ice management in Thunder Bay Harbour, winter 1984, volume I, Cannon bubbler experiments, Arctec Canada Ltd.
Draft (TP 5835E), Ice management in Thunder Bay Harbour, winter 1984, volume II, Manitoba Pool 1 dock load experiment, Arctec Canada Ltd.

Rake bubbler under test in Thunder Bay

Schedule: January 1981 — October 1984

Funding: TDC —	$293,800
CMTA —	$210,000
Transport Canada Energy Program —	$ 80,700
Total —	$584,500

Project Numbers: 4268-9, 4563, 4600, 4809, 6054, 6115
File Numbers: D-1460-145-2, D-1460-190
Project Officer: Roy S. Nishizaki

GENERAL
MARINE
RESEARCH

Energy-Efficient Ships: A Documentation Study

Description

Canada's merchant marine fleet operates at an economic disadvantage. A large proportion of the fleet consists of older vessels employing pre-1970 technology, resulting in inefficient use of fossil fuels and higher operating costs when compared to ships of current design and up-to-date technology.

This project involved documenting and analyzing worldwide state-of-the-art marine technology. The contractor investigated both the present practices of the marine industry as well as projections through the 1990s. The project methodology included literature searches and visits or correspondence with ship operators, designers, and builders and government agencies in Canada and abroad. The study addressed all pertinent aspects of ship design and operation affecting fuel efficiency.

Because the majority of Canadian registered vessels are built for operation in the Great Lakes, the study considers the greatest reduction in total fuel consumed by Canadian marine transportation is to be made by improvements to the lakers. There currently is an overall trend for lake ships to be propelled by slow-speed, heavy fuel burning diesel engines rather than by traditional steam turbines. It is probable, however, that the combination of a medium-speed engine and a slow-speed diesel engine, in the father/son configuration, will make for the most economical propulsion system for lakers.

From work carried out in this study, it is apparent that every vessel must be assessed in its own right in order to arrive at the most economical propulsion system for that ship. In addition, it concludes that alternative fuel technology is not in an advanced stage of development and is not suitable for ship application at present. The most promising form of ship propulsion system that can be developed using alternative fuels is the closed cycle gas turbine system supplied with heat by a coal-fired, fluidized bed boiler.

Wind power was also looked into. It has been shown to be a practicable means of augmenting the propulsion of small ships fitted with diesel engines as their primary power source. But, it is considered highly improbable that a wholly wind-powered ship will be built, although such a vessel is technically feasible.

This comprehensive study should prove useful to Canada's marine transportation policymakers and encourage Canada's marine and related industries to develop innovative approaches to the design of energy-efficient ships.

Progress to July 1984

Technical work has been completed; a report is in preparation.

Contractor

Melville Shipping Ltd., Calgary, Alberta

Report

Draft (TP 6168E), Development of marine technology for future energy-efficient ships, Melville Shipping Ltd.

Schedule: March 1983 — February 1985
Funding: Transport Canada Energy
Program — $98,775
Project Number: 4937
File Number: D-1460-100
Project Officer: Richard Bertrand

Alternative Fuels for Marine Propulsion

Description

Canada has a vested interest in the investigation of alternative fuels, which would enable Canadian vessels to be less dependent on the relatively scarce liquid petroleum fuels. Both liquified natural gas (LNG) and compressed natural gas (CNG) have been identified as alternative fuels that could potentially meet Canadian economic and long-term supply needs.

In this project, the feasibility of CNG as an alternative marine fuel was investigated. The contractor selected the Canadian ferry system as a suitable candidate for this in-depth study. Extensive research was conducted into the types of equipment and material likely to be used in the storage, handling, and consumption of CNG. The contractor then designed storage and handling systems appropriate to Canadian shipping needs. Finally, preliminary designs of certain ships similar to those used in Canada were developed, to show how overall design can be influenced by the fuel type used.

The results of this study suggest that operating a CNG dual-fueled ferry on shorter routes on the West Coast would be both technically and economically feasible. B.C. Ferry Corporation is planning to convert and implement a CNG-fueled service.

Progress to July 1984

This project has been completed.

Contractor

IBI Group, Vancouver, British Columbia

Report

TP 5551E, Alternative fuels for marine propulsion: compressed natural gas, IBI Group, 1984.

Schedule: November 1983 — July 1984
Funding: Transport Canada Energy

Program —	$83,000
CN Marine —	$10,000
Total —	$93,000

Project Numbers: 4246, 6186
File Number: D-500-600-6
Project Officer: Roy S. Nishizaki

Energy-Efficient Tug and Barge

Description

Tug and barge transportation is widely used by forestry and other resource-based industries in British Columbia. The existing fleet of tugs and barges imposes a cost burden that could be alleviated by more fuel-efficient and refined tug and barge systems.

This project is concerned with the development and evaluation of energy-efficient barge forms that use a low resistance skeg to achieve towing stability. Models of improved barge forms and tug designs will be incorporated into a model tug/barge system. This system will be self-propelled and radio controlled, and tested under appropriate weather conditions in open waters.

Specific work on this project includes:

- hydrodynamic tank testing of a refined low resistance barge form and an optimized tug model;
- computer-based parametric analyses;
- mathematical simulations of towline resistance;
- an instrumented test program with the tug/towline/barge system self-propelled in open water; and
- comparative testing of a self-propelled hull form model.

Progress to July 1984

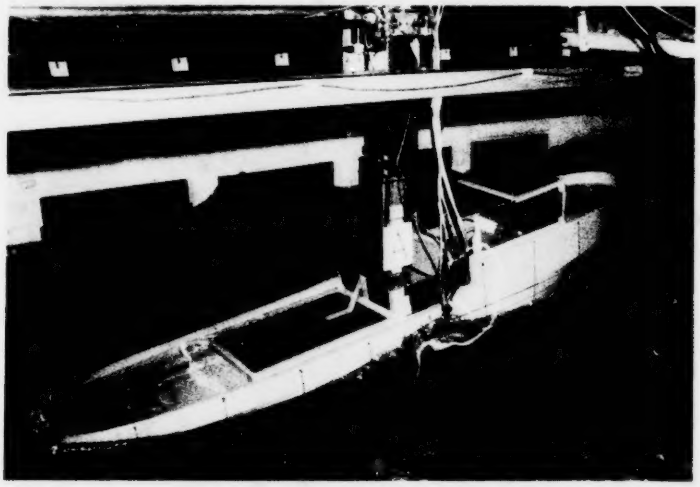
Tank testing of the barge form and towline elements has been completed. Construction of the instrumented, self-propelled tug model is in progress.

Contractor

Seatronics Technology Ltd., Burnaby, British Columbia

Report

None to date



Tank testing of energy-efficient tug model

Schedule: October 1983 — May 1985
Funding: CMTA — $148,000

Project Numbers: 6102, 6103
File Number: D-1460-180-2
Project Officer: Ian M. Bayly

R.B. 211 Combined Cycle Study

Description

Significant improvements in the efficiency of Canada's marine propulsion plants can be realized with the use of a gas turbine, combined cycle system. For this reason, TDC has supported the development of a combined cycle propulsion plant for Dome open water LNG ships.

In this project, the contractor prepared the preliminary installation design and performance specification for a propulsion plant using the Rolls-Royce Canada R.B. 211 gas turbine. One important condition in designing the plant was the use of Canadian components wherever possible.

Following the design phase, a comparison was made between the R.B. 211 combined cycle system and an all-steam driven propulsion plant. The principle features compared were:

- optimum plant performance relative to ship speed and operating profile,
- installation design,
- reliability,
- maintenance, and
- capital and operating costs.

Results of this multi-factored comparison found the combined cycle propulsion system to be a feasible and potentially more fuel-efficient alternative to the all-steam system.

Progress to July 1984

Technical work has been completed; reports are in preparation.

Contractor

Rolls-Royce Canada Ltd., Montreal, Quebec

Reports

Draft (TP 5586E), Combined cycle propulsion system for LNG carriers, based on R.B.211 gas turbines, final report, Rolls-Royce Canada Ltd.
Draft (TP 5587E), Combined cycle propulsion system for LNG carriers, based on R.B.211 gas turbines, summary report, Rolls-Royce Canada Ltd.

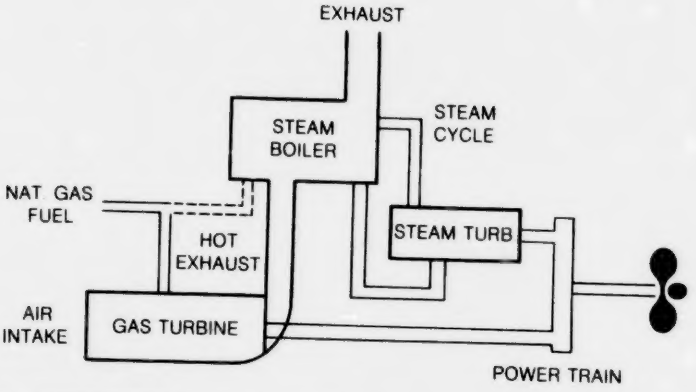


Diagram of combined cycle propulsion system

Schedule: July 1983 — January 1984
Funding: Transport Canada Energy Program — $30,000

Project Number: 6058
File Number: D-1450-143
Project Officer: C. Alfred Versailles

Welding Methods for Aluminum

Description

The value of aluminum as a structural material is limited by the welding difficulties it presents. Distortion through application of intense heat is a major problem in welding thin sheets of aluminum, and the weld quality poses problems in thicker sections.

Although these problems have been overcome to some extent in the past by pulsing the current between low and high values, giving a lower average current, the range over which the system operates is still very limited. The Welding Institute of Canada, however, has been using a variable frequency for gas metal arc welding on high-strength, low-alloy steels. Preliminary work on aluminum indicates that minor modifications to this equipment would make it suitable for use with aluminum.

The project involves the testing of a modified prototype of the equipment on thin sheets of aluminum of the type used in lightweight rail cars, and thicker plates used in ship construction. The test results will be compared between the pulsed and the conventional gas metal arc welding. Variables will include pulse duration, peak current, wire diameter, background current, voltage, and wire feed rate. Prime consideration for thin section material will be the level of distortion and control of "burn through." The integrity of the weld for thick sections will be tested. Bend testing, transverse tensile testing, and hardness evaluation will follow.

Design modifications for the commercial market will also be prepared.

Progress to July 1984

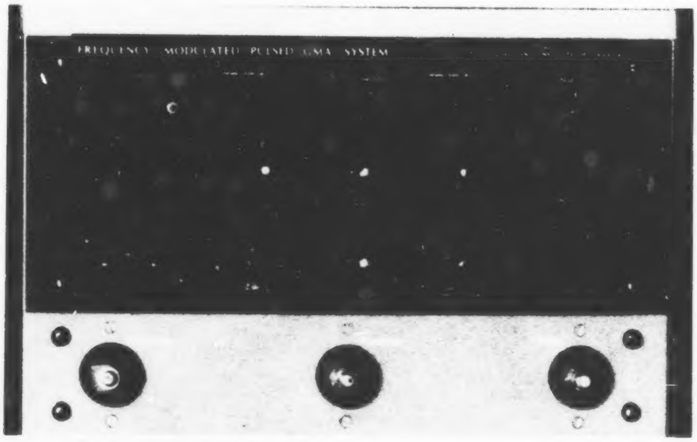
The prototype of the equipment has been built, and welding tests are underway.

Contractor

Welding Institute of Canada, Oakville, Ontario

Report

None to date



Prototype aluminum welder

Schedule: August 1983 — March 1986
Funding: TDC — $142,700

Project Number: 6126
File Number: D-1460-212
Project Officer: Roy S. Nishizaki

Hydrostatic Stern Tube Bearing

Description

Failure of the stern bearing, supporting the propeller shaft as it passes through the hull, is a major cause of ship casualty.

This problem may be pronounced if conventional hydrodynamic stern tube bearings are used to support heavy slow-turning shafts of large ships operating in ice-infested waters.

The hydrostatic bearing under development avoids wear by maintaining clearance between the shaft and the bearing surfaces. The system also offers the opportunity to reduce alignment problems by permitting bearings of shorter length than normally dictated by standard practice.

A model bearing, representing in 1:5 scale the bearing of a modern supertanker, has been built and subjected to 160 hours of testing at the Naval Engineering Test Establishment of the Department of National Defence, Montreal. Adequate clearance was maintained under continuous and vibratory loading beyond design limits. The dynamic coefficient of friction measured during tests was less than 0.0023.

Progress to July 1984

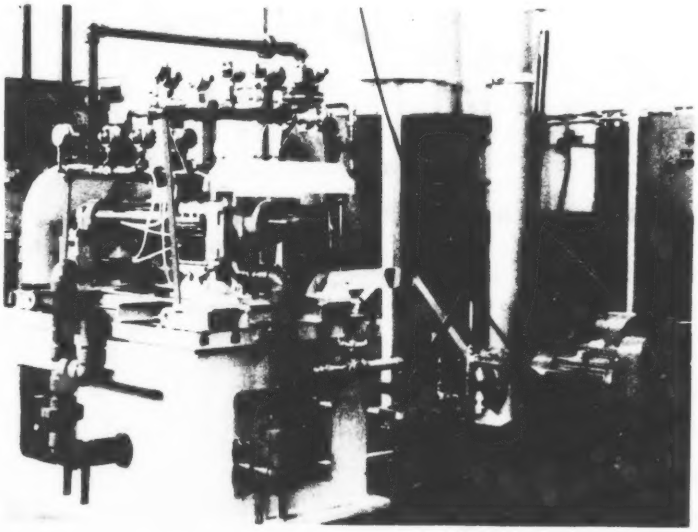
Testing of the bearing was completed in May 1984. Sea trials are being planned with the installation of a hydrostatic bearing, and its associated systems, in a Canadian Coast Guard ship.

Contractor

Peacock Inc., Montreal, Quebec

Report

None to date



Testing vibratory and eccentric thrust effects of a 1:5 scale model of the hydrostatic stern tube bearing

---

Schedule: July 1981 — September 1984
Funding: TDC-AAMP — $407,000

Project Number: 4474
File Number: D-1460-162
Project Officer: N.R. Gore

Concrete Paving Blocks for Marine Terminals

Description

Modern cargo handling equipment can impose heavy loads on port pavement, particularly when container moving equipment is used. Operating and maintenance costs are high because surfaces deteriorate rapidly. The aim of this project is to evaluate the economic and performance advantages of concrete paving blocks over asphalt paving for heavy duty use in marine terminals. These blocks combine the flexibility of asphalt pavement with the strength and oil resistance of rigid concrete pavement.

Following a review of international experience with concrete block pavement and an economic comparison between these and other pavement types, the contractor designed and installed six test sections at the Port of Montreal. These sections have been monitored periodically since their installation in 1982. As two years is too short to judge the long-term performance of paving blocks under actual load and environmental conditions, TDC is funding a new study extending the testing period to spring 1987. At that time, the contractor expects to have sufficient data to predict future behavior of the sections and recommend design methods for future pavement construction.

Progress to July 1984

Monitoring of the test sections is continuing.

Contractor

Centre de recherche et de contrôle appliqué à la construction Inc., Montreal, Quebec

Report

TP 5344E, Structural evaluation and design of block pavements for container terminals, Centre de recherche et de contrôle appliqué à la construction Inc., 1984.

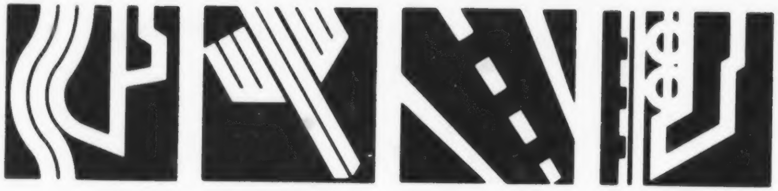
Concrete paving blocks combine flexibility of asphalt with durability of concrete

---

Schedule: November 1981 — October 1987
Funding: TDC — $ 88,000
Port of Montreal — $153,000
Total — $241,000

Project Number: 4464
File Number: D-1465-346
Project Officer: Catherine Hirou[illegible]

REPORT
LISTING



Report Listing

This list includes the titles of TDC reports printed in 1984. These reports may be ordered free-of-charge from TDC while supplies last.

A list of the Centre's reports published before 1984 is given in "TDC Publications" (TP 2602), available upon request from TDC.

Reports may also be borrowed through interlibrary loan from the TDC library in Montreal or from the Transport Canada Library and Information Centre, Transport Canada Building, 2nd floor, Ottawa, Ontario K1A 0N5. The Transport Canada Library and Information Centre provides paper copies of out-of-print reports at a charge of 20¢ per page. Paper copies and microfiche of out-of-print reports are also available at various charges from Micromedia Ltd., 144 Front Street West, Toronto, Ontario, M5J 1G2, telephone (416) 593-5211.

Rail

Augmented rail freight transportation research and development program, by Transportation Development Centre, 1984. TP 3756E

Canadian railway motive power: performance targets and hybrid benefits evaluation — a working paper, by G.W. English, C. Schwier and J.D. Young, Canadian Institute of Guided Ground Transport, 1984. TP 5380E

Conceptual design of snow removal equipment for main tracks, by A. Van Eyken and S. Perlin, Canadian Institute of Guided Ground Transport, 1984. TP 5289E

Container terminal simulation model: user's manual, by M.A. MacIsaac, E.D. Brown, G.W. Skelton et al., Canadian National Railways, 1984. TP 5758E

The cost of rail passenger services in Canada: an examination of institutional problems, by Adil Cubukgil and Richard M. Soberman, University of Toronto-York University, 1984. TP 5823E

Electric locomotive evaluation, by E.R. Corneil, G.W. English and H. Boumeester, Canadian Institute of Guided Ground Transport, 1984. TP 5589E

Étude technique d'un terminal intermodal, rapport sommaire, par C.J.M. Ives, J.C. Dale et al., CP Ltée, 1983. TP 4484F

Flashing lights and bells at grade crossings: present problems and directions for the future, by Ezra Hauer, University of Toronto, 1984. TP 5308E

Les géotextiles et la remise en état des voies ferrées, par G.P. Raymond, W.J. Purdy, B.S. Gerry et al., Canadian Institute of Guided Ground Transport, 1982. TP 3647F

Human factors in rail passenger car design, by Tom Hay and Ben Barkow, Behavioural Team, 1984. TP 5488E

Hunting and curving performance of rigidized elasto-cushion trucks, by R. Gonsalves, G. Izbinsky and H. Soares, CP Ltd., 1984. TP 5477E

Improved train control transponder, by R.J. Pomeroy, Glenayre Electronics Limited, 1983. TP 5033E

Intermodal terminal design study, final report, 2 volumes, by C.J.M. Ives, J.C. Dale et al., CP Ltd., 1983. TP 4059E

Intermodal terminal design study, summary report, by C.J.M. Ives, J.C. Dale et al., CP Ltd., 1983. TP 4484E

Localisation potentielle des gares multimodales de voyageurs au Canada, 2 volumes, par L. Demers, A. Lachapelle, C. Lardinois et al., Beauchemin-Beaton-Lapointe Inc., 1983. TP 4913F

Location, identification and control system application to mainline railroads, summary report, by R.C. Chillman and R.J. Pomeroy, Glenayre Electronics Ltd., 1983. TP 5217E

Le moteur à cycle de Stirling adapté à la traction ferroviaire, rapport sommaire, par G. Walker, Whitegates Engineering Ltd., 1981. TP 3242F

A ride monitor system for maintaining a fleet of railway passenger cars, by P. Marcotte, J.T. Wilson and K.J.R. Mathewson, DSL Dynamic Sciences Ltd., 1984. TP 5323E

Surface

Arctic snowmobile design study, by Dr. P.J. Poole, Nunasi Corporation, 1984. TP 5498E

Arctic snowmobile design study, summary report, by Peter J. Poole, Nunasi Corporation, 1984. TP 5728E

Characteristics of truck combinations with the double drawbar dolly, by J.H.F. Woodrooffe and J.R. Billing, Roads and Transportation Association of Canada, 1984. TP 5022E

Electric road vehicles in Canada: an outline of the government of Canada's role, by John H. Morgan, Transportation Development Centre, 1984. TP 5222E

Étude technique d'un terminal intermodal, rapport sommaire, par C.J.M. Ives, J.C. Dale et al., CP Ltée, 1983. TP 4484F

Évaluation en laboratoire de l'aptitude des mélanges ciment-cendres volantes et ciment-lignocellulose à stabiliser les sols, rapport sommaire, par M.D. Graham et C.B. Dawley, EBA Engineering Consultants Ltd., 1984. TP 5288F

Évaluation et perfectionnement de véhicules routiers électriques, rapport sommaire, par D.G. Andres et E. Waddington, DSMA ATCON Ltd., 1982. TP 3805F

Fabrication, test, calibration and evaluation of a road roughness measuring device, by B.R. Campbell, Highway Products International Inc., 1983. TP 4851E

Flashing lights and bells at grade crossings: present problems and directions for the future, by Ezra Hauer, University of Toronto, 1984. TP 5308E

Intermodal terminal design study, final report, 2 volumes, by C.J.M. Ives, J.C. Dale et al., CP Ltd., 1983. TP 4059E

Intermodal terminal design study, summary report, by C.J.M. Ives, J.C. Dale et al., CP Ltd., 1983. TP 4484E

Localisation potentielle des gares multimodales de voyageurs au Canada, 2 volumes, par L. Demers, A. Lachapelle, C. Lardinois et al., Beauchemin-Beaton-Lapointe Inc., 1983. TP 4913F

La motoneige, véhicule utilitaire du grand nord: situation actuelle et perspectives d'amélioration, rapport sommaire, par Dr. P.J. Poole, 1982. TP 3728F

Optimization of propane engines for light duty vehicles — phase I, by G.A. Lacy, R.C. Motta, T.R. Willsie et al., Chrysler Canada Ltd., 1984. TP 5171E

A safety manual for propane bus systems, by Dr. R.F. Webb, R.F. Webb Corporation Ltd., 1984. TP 5493E

Système d'annonce automatique aux voyageurs, par N. Laberge, Bureau de transport métropolitain international Inc., 1983. TP 4744F

Tests of the Neo-Ken switched reluctance motor, by W.K. Lacey, DSMA ATCON Ltd., 1984. TP 5417E

Traffic signals: left turn phasing and displays, vehicle clearance intervals, flashing operations: state-of-the-art, by K.G. McLean et al., DeLCan, 1984. TP 5324E

Transport par conduites du charbon broyé gros essais sur pipe-lines en vraie grandeur, rapport sommaire, par G. Gillies, D.B. Haas, M.H. Small et al., Saskatchewan Research Council, 1983. TP 4485F

Air

Appareil ADAC à consommation spécifique améliorée — phase III, rapport sommaire, par B. Eggleston et R.J.D. Poole, de Havilland Aircraft of Canada Ltd., 1983. TP 5055F

Détecteur embarqué pour la pesée et le centrage des avions, rapport sommaire, par R. Young, K.J.R. Mathewson et D.C. MacEachern, DSL Dynamic Sciences Ltd., 1983. TP 4368F

Development of a prototype of a helicopter voice advisory system: VADIS, by Walter Shawlee, Northern Airborne Technology, 1984. TP 5461E

Development potential for the 150-seat new technology aircraft for the 1990's, summary report, by A. Elek, L.R. Murdoch and R.W.J. Sturgess, Peat, Marwick & Associates, 1983. TP 5231E

Microwave landing system azimuth antenna subsystem, by M. McAloney, M. Senechal, M. Tough et al., Micronav Limited, 1984. TP 5519E

Microwave landing system azimuth antenna subsystem, summary report, by M. McAloney, M. Senechal, M. Tough et al., Micronav Limited, 1984. TP 5520E

Offshore airport concepts servicing the East Coast energy resource industry, main report, by George J. Sladek et al., IBI Group Inc., 1983. TP 5047

Offshore airport concepts servicing the East Coast energy resource industry, summary report, by George J. Sladek et al., IBI Group Inc., 1983. TP 5048E

Projet et évaluation d'une installation UNAVCOM II, rapport sommaire, par D. Friberg, Canadian Astronautics Ltd., 1983. TP 4696F

Marine

Air cushion icebreaking bow (ACIB) operations report: 1983/84, by J.A. Tarzwell, P. de L. Markham and T. Anderson, German and Milne Inc., 1984. TP 5497E

Alternative fuels for marine propulsion — compressed natural gas, by C. Clapham, IBI Group Inc., 1984. TP 5551E

Arctic marine design and construction handbook, 2 volumes, by J.C. Chakraburtty, H.R. Kivisild, L.H. Macphie et al., Fenco Consultants Ltd., 1984. TP 5727E

Cargo brise-glace Arctic: saisie des données et instrumentation — fin de saison de navigation de 1981, rapport sommaire, par H. Blount, I. Glen et M. Steele, Arctec Canada Ltd., 1982. TP 3645F

Cargo brise-glace Arctic: saisie des données et instrumentation — saison de navigation 1980, rapport sommaire, par V.W. Neth et D.H. Boteler, Fenco Consultants Ltd. et German and Milne Inc., 1981. TP 3522F

Essai et évaluation du système NAWS de détection des niveaux de contrainte dans la coque du brise-glace canadien Pierre Radisson, rapport sommaire, par A. Benjamin, German and Milne Inc., 1984. TP 5317F

Étude documentaire d'un facteur climatique: le climat des vagues, rapport sommaire, par W.F. Baird et K.R. Hall, W.F. Baird & Associates Coastal Engineers Ltd., 1982. TP 3900F

Évaluation et conception des chaussées en pavés pour terminaux marins, par J. Hode Keyser, Centre de recherche et de contrôle appliqué à la construction, 1984. TP 5344F

Feasibility study of mechanical ice break and removal techniques, by R.K. Watanabe and B.P. Garrett, Martec Ltd., 1984. TP 5611E

Flow trajectories about an air cushion icebreaking bow, by P. Markham, German and Milne Inc., 1984. TP 5350E

Inspection and evaluation of the Canadian Coast Guard air cushion icebreaking bow, by C. Carter, German and Milne Inc., 1984. TP 5079E

Mise au point d'un système d'inspection sous-marine au moyen de caméra vidéo que l'on remorque, par Guy Grenier, Pelchat Grenier Géomarine Inc., 1983. TP 4736F

Model tests of ice cutting patterns, by J.B. Fitzpatrick and R.J. Gill, Acres Consulting Services Ltd., 1984. TP 5604E

Modelling of heat flow in ships, by Dr. A. Firmin, H.G. Engineering Ltd., 1983. TP 5001E

Modelling of heat flow in ships, summary report, by Dr. A. Firmin, H.G. Engineering Ltd., 1984. TP 5232E

M.V. Arctic data acquisition system review report, by T.H. Peirce, T.K. Gillies, J.C. Peirce et al., Operational Dynamics, 1984. TP 5257E

M.V. Arctic ice transiting performance in the ramming mode, final report, by A.M. Nawwar and L. Goossens, Arctec Canada Ltd., 1984. TP 5320E

M.V. Arctic master data package, 1979-1980-1981 seasons, summary report, by J.G. German, A. Benjamin, J.F. Stirling et al., German and Milne Inc., 1982. TP 3894E

Répertoire des données recueillies à bord du cargo brise-glace Arctic: saisons de navigation 1979-1980-1981, rapport sommaire, par J.G. German, A. Benjamin, J.F. Stirling et al., German and Milne Inc., 1982. TP 3894F

A review of steel properties at low temperatures, summary report, by G. Almond, G. Gauthier and A.E. Wright, Fenco Consultants Ltd., 1982. TP 3790E

Structural evaluation and design of block pavements for container terminals, by J. Hode Keyser, Centre de recherche et de contrôle appliqué à la construction, 1984. TP 5344E

Test and evaluation of NAWS: hull stress monitor on CCGS Pierre Radisson, by A. Benjamin, German and Milne Inc., 1984. TP 5322E

Test and evaluation of NAWS: hull stress monitor on CCGS Pierre Radisson, summary report, by A. Benjamin, German and Milne Inc., 1984. TP 5317E

Transportation for the elderly and the handicapped

Disabled group transportation vehicle: an evaluation of user demand, vehicle requirements and funding sources, by Peter Kaulback, DeLCan, 1984. TP 5291E

Répertoire du matériel de transport pour les personnes à mobilité réduite, par Barbara A. Smith et Roy S. Nishizaki, Centre de développement des transports, 1981. TP 3618F

Stairway lift assessment: an evaluation of selected automated inclined stairway elevating devices for use in transportation terminals, by Peter Kaulback, DeLCan, and Ruth Heron, Transportation Development Centre, 1984. TP 5290E

General

Évaluation en laboratoire de l'aptitude des mélanges ciment-cendres volantes et ciment-lignocellulose à stabiliser les sols, rapport sommaire, par M.D. Graham et C.B. Dawley, EBA Engineering Consultants Ltd., 1984. TP 5288F

Feasibility and design: a Vancouver area integrated transportation information system, by D. Spaeth, Mayali Consultants, and G.W. Bachmayer, B.C. Ministry of Energy, Mines and Petroleum Resources, 1984. TP 5365E

Publications du CDT/ *TDC Publications,* édition d'août 1984/August 1984 edition, par/by CDT/TDC. TP 2602

La sécurité des transports: un cadre pour la planification de la recherche et du développement, par M. Kieran, R. Allingham et J. Woods, Peat, Marwick et Associés, 1983. TP 5046F

Structuration du programme du CDT de 1983/1984 à 1987/1988, document de travail, par CDT, 1982. TP 5198F

TDC Publications/ *Publications du CDT,* August 1984 edition/édition d'août 1984, by/par TDC/CDT. TP 2602

Transportation
Development Centre

Guy Favreau Complex
200 Dorchester Blvd. West
Suite 601, West Tower
Montreal, Quebec
H2Z 1X4

Canada

POOR

QUALITY

ORIGINAL